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THESIS

IMPACT OF U.S. NAVAL VESSEL MOVEMENTS WITHIN SAN FRANCISCO BAY AREA ON NAVAL SUPPLY CENTER OAKLAND'S TRANSPORTATION SYSTEM

by

Gary John Angelopoulos

September 1979

Thesis Advisor: A. W. McMasters
Thesis Co-Advisor: E. F. Roland

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IMPACT OF U.S. NAVAL VESSEL MOVEMENTS WITHIN THE SAN FRANCISCO BAY AREA ON NAVAL SUPPLY CENTER OAKLAND'S TRANSPORTATION SYSTEM

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ABSTRACT

This simulation is a versatile SIMSCRIPT program designed to determine transportation destination fluctuations caused by U.S. Naval vessel movements in the San Francisco Bay Area. The through-put model was designed to investigate the relationship between the annual number of delivery trips and the average material delivery delay. Numerous parameters have been taken into consideration in the generation of a model that is as realistic as possible. Requirement priority, item quantity, customer movement, ultimate destination, and process time are the significant random variables which have been assigned probabilistic distributions. In view of the simulation results, it would appear that actual modification of the current shipping parameters may yield substantial transportaion savings.

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I. INTRODUCTION

A. BACKGROUND

Naval Supply Center (NSC), Oakland, California is one of five major support facilities in the United States Navy. Approximately 600,000 line items have been positioned at NSC Oakland to provide material support to active and reserve fleet units, local and overseas shipyards, naval air stations, several overseas depots, and numerous smaller commands. It also has the capability of responding effectively to a wide variety of functional tasks. Those services provided include accounting functions, household goods storage and movement, central area procurement, operation of a fuel support facility, and support to foreign governments.

NSC Oakland is further tasked with implementing these mission requirements over a vast area of the globe. In fact, it includes the Pacific Ocean (Hawaii Area excluded), the Indian Ocean, and Northern California.

In Northern California, direct support is provided to 174 local commands. The size of these commands varies from a major shipyard to small boats, and within this spectrum there is a group of unique customers. They are U. S. Naval vessels which are mobile; each ship may be found at several different locations during the course of a year. Such movement has impact on the material segregation function and the transportation requirements of NSC Oakland. During

fiscal year 1978, seventeen vessels represented those local customers whose transportation destinations varied significantly. Many more than seventeen ships are homeported in the Bay Area. However, the other vessels, when present, always berthed at the same location. Thus, their delivery distance requirements were known. The seventeen mobile customers include:

Eight Auxiliary Ammunition Vessels (AE's),

Three Auxiliary Refrigerated and Stores Vessels (AFS's),

Three Auxiliary Oiler and Replenishment Vessels (AOR's),

Two Mine Sweeper Ocean Vessels (MSO's),

One Auxiliary Repair Vessel (AR).

Table 1 is a statistical review of all vessels requisitions as documented in the Historical Demand File at NSC Oakland from September 1977 to September 1978. It amplifies the relative significance of vessel support on both a local and global level. Those vessels marked by a "*" berthed at more than one location in the bay area during the year.

Table No. 1. LOCAL VESSEL DEMAND DATA
FROM 9/77 TO 9/78

SHIP CLASS	NUMBER OF VESSELS	NUMBER OF DEMANDS	PERCENT OF LOCAL	PERCENT OF GLOBAL
CV	2	83359	12.9269	3.8635
DD	1	2413	.3742	.1118
FF	3	22481	3.4862	1.0420
SS	11	18622	2.8878	.8631
LKA	1	4116	.6383	.1908
WHEC	5	4628	.7177	.2145
WPB	5	426	.0661	.0197
AE*	8	46422	7.1989	2.1516
AFS*	3	46425	7.1993	2.1517
AOR*	3	25194	3.9069	1.1677
AR*	1	35767	5.5466	1.6577
MSO*	2	3926	.6088	.1820
TOTALS*	17	157734	24.4600	7.3106
TOTALS	45	293779	45.5576	13.6160

The seventeen mobile ships represented 24.46 percent of NSC Oakland's local business as shown in Table 1. The ships in this group were found to change location from as few as four to as many as eighteen times in a one year period (It should be noted that trips in which vessels returned to their place of departure were not included) . A mobile customer located at NSC Oakland today may be found tomorrow at the Naval Weapons Station Concord, some thirty-three miles away. Thus, over a short period of time, transportation requirements may materialize or disappear. Such fluctuations have had a significant impact on the Bay Area Local Delivery (BALD) system which transports material from NSC Oakland to these ships.

B. OBJECTIVE

It is the intent of this paper to quantify, through simulation, the impact of local mobile customers on the transportation requirements of NSC Oaklands' Bay Area Local Delivery system (BALD).

C. SCOPE

Simulation was chosen as the technique for evaluation of this problem for the following reasons: 1. The actual material transportation requirements for the mobile customers were not available, and the cost to obtain such data was considered to be prohibitive; 2. Alternative delivery schemes can be evaluated prior to imposing them on the actual system.

Only those previously identified local vessels, their movements, and the associated NSC Oakland material support during the year from September 1977 to September 1978 was considered in this simulation.

The decision parameters utilized included both empirical distributions and classical distributions. They were developed through the use of histograms and standard data analysis techniques. However, when data was limited, some distributions were subjectively developed. This approach was taken under the assumption that it was better to utilize what information was available, rather than to use entirely arbitrary values.

II. ASSUMPTIONS AND PARAMETER EVALUATIONS

Exact identification and quantification of all simulation parameters and variables is not only a formidable task but, in general, an impossible one. It is apparent that any process complex enough to warrant computer simulation will also require simplifying assumptions. In the interest of realizing a viable finding within a constrained time period and with limited assets, numerous suppositions were required. Whenever possible, each premise has been analytically or logically justified in the following subsections.

A. MOBILE CUSTOMERS

The vessel movement data analyzed was extracted from fifty-four weekly Ships Information Bulletins (NASUPPACT-30) published by the Naval Support Activity, Treasure Island, San Francisco, California. Appendix A is an example of one such bulletin.

Figure 1 is a graphical representation of the operating cycles of the seventeen port-mobile vessels for fiscal year 1978. It is the basis of the vessel mobility section of the simulation.

1. Ship Movement

Ship movement between local Bay Area ports was

assumed to be a Markov Process. As a consequence, knowledge of past movements of a vessel will not change the probability of moving from one location to another or, stated differently, the system is memoryless and will not modify future behavior because of knowledge of past movment. Thus, a stochastic matrix of the transition process from one location to another was constructed.

Since ships of the same class (for example, Auxiliary Ammunition Vessels) are operationally funded at the same level, operate with similar life cycles, perform the same mission, and are manned at the same compliment; ship movements were aggregated by class and Markov chains were developed for each class.

Figures 2, 3, 4, 5, and 6 show the matrices for each ship class. They were developed by first identifying the ports visited by each ship class. Those ports were then annotated on the left vertical and top horizontal sides of the class matrix. Next, these vessels' movements (Figure 1) were annotated in the matrix as follows: a. The initial location of a vessel was identified on the left vertical side of the matrix; b. The location that this vessel next moved to was then noted at the top horizontal side of the matrix; c. A check mark was then entered within the matrix based on these two locations. This procedure was then repeated using this ship's new location as the left vertical starting port of the matrix. When all the vessel movements within a class had been processed, the probabilities of movement from one location to another were determined across each row of the matrix by dividing all elements' values (sum of a group of check marks) in a row by the total row sum.

If one were interested in determining the probabilities where a AFS would be expected to move given it is at Alameda, Figure 4 would be utilized. Starting with

NAS Alam on the left vertical side one would move along this row and note that there is a sixty percent chance of going to NSC Oakland or a forty percent chance of deploying.

2. In Port Duration

It was assumed that in-port duration times were independent of ship type, but were a function of their associated location. Thus, these times were aggregated by location and probabilistic distributions were assigned. It should be noted, that a scarcity of data and difficulties in fitting this data has resulted in some uncertainty about these distributions.

If a ship was conducting local operations and returned to its departure location, it was considered located at that port for the time period under investigation. However, if a vessel departed and returned to another local port, the time in local transit/operations was included in the arriving location calculation. These time periods were included in the in-port computations because it was assumed that material not delivered prior to a vessels departure would be delivered to the vessels "new" location, and any material requirements received for an underway vessel would be sent to the "new" port. Also, if a vessel departed from a location and did not return to a local port within sixty days, it was assumed that it was on a eight-month deployment to the Western Pacific.

The following results represent the number of in-port periods contained in each time interval and is a general overview of the time frequency results. The in-port time interval corresponds to a cell in table 2. In-port time intervals were determined by first calculating the in-port time periods for all vessels which visited each

port. These periods were then sorted by port. Time interval (cells) were next selected which would result in approximately five in-port duration observations per cell. Due to the extreme spread of the data it was not possible to display the complete cell data for all ports. In some cases so few data points were available that the above procedure could not be done, and these cases were ommited from the Table. In other cases extreme values were observed which were more than double the next largest value. These values were in general considered outliers and were truncated from the data set.

For example, the in-port durations for NAS Alameda were calculated utilizing Figure 1. They were then ordered and analyzed. The data was segmented into two groups. Table 2 shows the first three cells of this segmentation. In this case, each cell represents four days. The remainder of the distribution was also observed to be uniform (no significent upward or downward trends) and they ranged from twenty-seven to one-hundred and twenty-nine days.

Table No. 2. IN-PORT FREQUENCY DATA

PORT	CELL 1	CELL 2	CELL 3
ALAMEDA	5	4	5
MARE IS	6	5	5
OAKLAND	6	5	
CONCORD	7	4	2
TREASURE IS	6	5	5
DEPLOYED	8	7	

These results are presented as a partial explanation of the subjective determination of the in-port time distributions. Upon completion of the inter-departure time analysis, probabilistic distributions were assigned by

geographic location as follows:

a. Naval Station Alameda: The in-port time is uniformly distributed between four and seventeen days with probability 0.5, and uniformly distributed between twenty-seven and one hundred twenty-nine days with probability .5.

b. Naval Weapons Station Concord: The in-port time was found to be exponentially distributed with the parameter equal to .0612.

c. NSC Oakland: The distribution was found to be uniform between nine and fifty-six days.

d. Naval Station Treasure Island: The in-port time is uniformly distributed between three and seventy-eight days.

e. San Francisco Shipyard: The maintenance time was seven days with a .65 probability, or was two-hundred-forty days with a .35 probability.

f. Todd Shipyard (Alameda): The time distribution was found to be uniform from thirty-eight to eighty-four days.

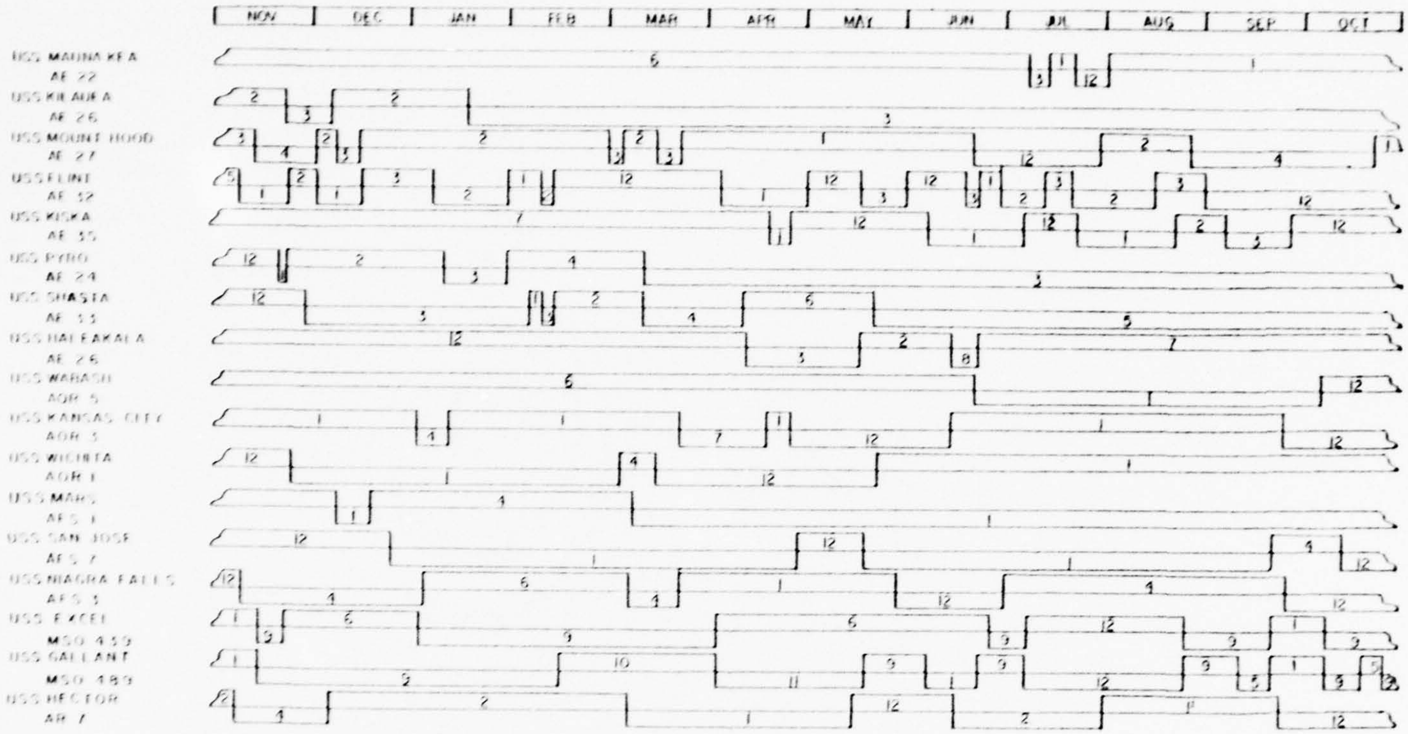
g. Bethlehem Steel Shipyard (San Francisco) : Maintenance periods were either thirty or one-hundred-eighty days with equal probability.

h. Triple A Shipyard (San Francisco) : In-port time was found to be seven days.

i. Merritt and Pacific Shipyards (Oakland) : Maintenance time was forty-four days for both locations.

j. Mare Island Naval Shipyard: The maintenance periods were uniformly distributed between three and twenty-eight days with probability .668 or uniformally distributed between forty-three and ninety-one days with a .332 probability.

k. Deployed: The time in this catagory was assumed to be uniformly distributed between fifteen and sixty days with probability .65, and was two hundred and forty days (eight-month deployment to the Western Pacific) with probability .35.



1 - NAVAL AIR STATION, ALAMEDA
2 - MARE ISLAND NAVAL SHIPYARD
3 - NAVAL WEAPONS STATION, CONCORD
4 - NAVAL SUPPLY CENTER, OAKLAND
5 - SAN FRANCISCO
6 - TODD SHIPYARD, ALAMEDA
7 - BETHLEHEM STEEL SHIPYARD, SAN FRANCISCO
8 - TRIPLE A SHIPYARD, SAN FRANCISCO
9 - NAVAL SUPPORT ACTIVITY, TREASURE ISLAND
10 - MERDITH SHIPYARD, OAKLAND
11 - PACIFIC DRYDOCK, OAKLAND
12 - DEPLOYED

Figure 1 - VESSEL SCHEDULE

	NAVAL AIR STAT ALAM	MARE IS. NAVAL SHPYD	NAVAL WEAPS STAT CONC	NSC OAK	SAN FRAN SHPYD	TODD SHPYD SAN FRAN	BETH SHPYD SAN FRAN	DEPLY
NAVAL AIR STAT ALAM		.4546	.2727					.2727
MARE IS. NAVAL SHPYD	.2000		.4000	.0133			.0667	.2000
NAVAL WEAPS STAT CONC	.1875	.4375		.1250				.2500
NSC OAK	.2500	.2500	.2500			.2500		
SAN FRAN SHPYD	1.0000							
TODD SHPYD SAN FRAN			.5000		.5000			
BETH STEEL SAN FRAN	1.0000							
DEPLY	.4545	.0910	.4545					

Figure 2 - AUXILIARY AMUNITION TRANSITION MATRIX

	NAVAL AIR STAT ALAM	NSC OAK	BETH SHPYD SAN FRAN	DEPLY
NAVAL AIR STAT ALAM		.3333	.1667	.5000
NSC OAK	.5000			.5000
TODD SHPYD SAN FRAN	1.0000			
BETH SHPYD SAN FRAN	1.0000			
DEPLY	1.0000			

Figure 3 - AUXILIARY REPLENISHMENT TRANSITION MATRIX

	NAVAL AIR STAT ALAM	NSC OAK	TODD SHPYD SAN FRAN	DEPLY
NAVAL AIR STAT ALAM		.6000		.4000
NSC OAK	.6000		.2000	.2000
TODD SHPYD SAN FRAN		1.0000		
TRPL A SHPYD SAN FRAN	1.0000			
DEPLY	.5000	.5000		

Figure 4 - AUXILIARY REFRIGERATED STORES MATRIX

	NAVAL AIR STAT ALAM	MARE IS. NAVAL SHPYD	NSC OAK	DEPLY
NAVAL AIR STAT ALAM				1.0000
MARE IS. NAVAL SHPYD	.6667		.3333	
NSC OAK		1.0000		
DEPLY		1.0000		

Figure 5 - AUXILIARY REPAIR TRANSITION MATRIX

	NAVAL AIR STAT ALAM	SAN FRAN SHPYD	T.I. NAVAL SUP ACT	MERRITT SHPYD OAK	PACIFIC DRY DOC OAK	DEPLY
NAVAL AIR STAT ALAM			1.0000			
SAN FRAN SHPYD	.5000		.5000			
TODD SHPYD SAN FRAN			1.0000			
T.I. NAVAL SUP ACT	.2222	.4445		.1111		.2222
MERRITT SHPYD OAK					1.0000	
PACIFIC DRY DOC OAK			1.0000			
DEPLY			1.0000			

Figure 6 - MINE SWEEPER OCEAN TRANSITION MATRIX

B. MATERIAL REQUIREMENTS AND PROCESSING

The material requirements and distribution processes experienced by NSC Oakland were reduced to a series of inter-related functions. The criteria for this breakdown was twofold: first, the function must be estimatable; and second, only realistic processes were considered.

Subsequent paragraphs discuss the various assumptions and procedures undertaken to quantify the inter-linking segments of the material pipeline under investigation.

1. Historical Demand File

Numerous mechanized data bases were available at NSC Oakland. However, after a detailed evaluation, it was decided that the Requisition Demand History File (RDHF) would provide the most useful data. The Requisition Demand History File is a readily available mechanized file encompassing transactions from two fiscal years. Figure 7 depicts the standard format of the file's five possible one-hundred character records. These records will be discussed below. This file is composed of those material actions (requisitions) which have been transferred from the Requisition Status File because of their historical significance. Both the Requisition Status File and the Requisition Demand History File are composed of records. The initial basic entry which establishes the record is a requisition and other pertinent data is subsequently added.

A record-by-record scanning of the Requisition Status File is conducted to determine which records should

be retained because of their historical value. The following decision parameters represent the significant catagories of records which are transferred to the RDHF[11]:

a. Requisitions issued with and without proof of shipment as follows: (1) if the record has been in the file sixty or more days, without proof of shipment, a Record Type four is assigned; (2) if the record has been in the file sixty or more days with proof of delivery and the issue group is one or two, a Record Type one is assigned; (3) if the record has been in the file thirty days or more with a proof of shipment and the issue group is three, a Record Type one is assigned.

b. Those records with an exception supply status (rejected/canceled) as follows: (1) requisitions in the file for sixty or more days and and in issue group one or two are assigned Type Code five; (2) requisitions in the file for thirty or more days and in issue group three are assigned a Type Code five.

c. Records which indicate the item was sent to purchase as follows: (1) if the record has been in the file ninety or more days without purchase order data and is in issue group one or two, or if the record has been in the file thirty days or more without purchase order data and is in issue group three, a Type Code three is assigned; (2) if the record has been in the file sixty days or more with purchase order data and the associated issue group is one or two or if the record has been in the file for thirty days or more and the issue group is three, a Type Code of two is assigned.

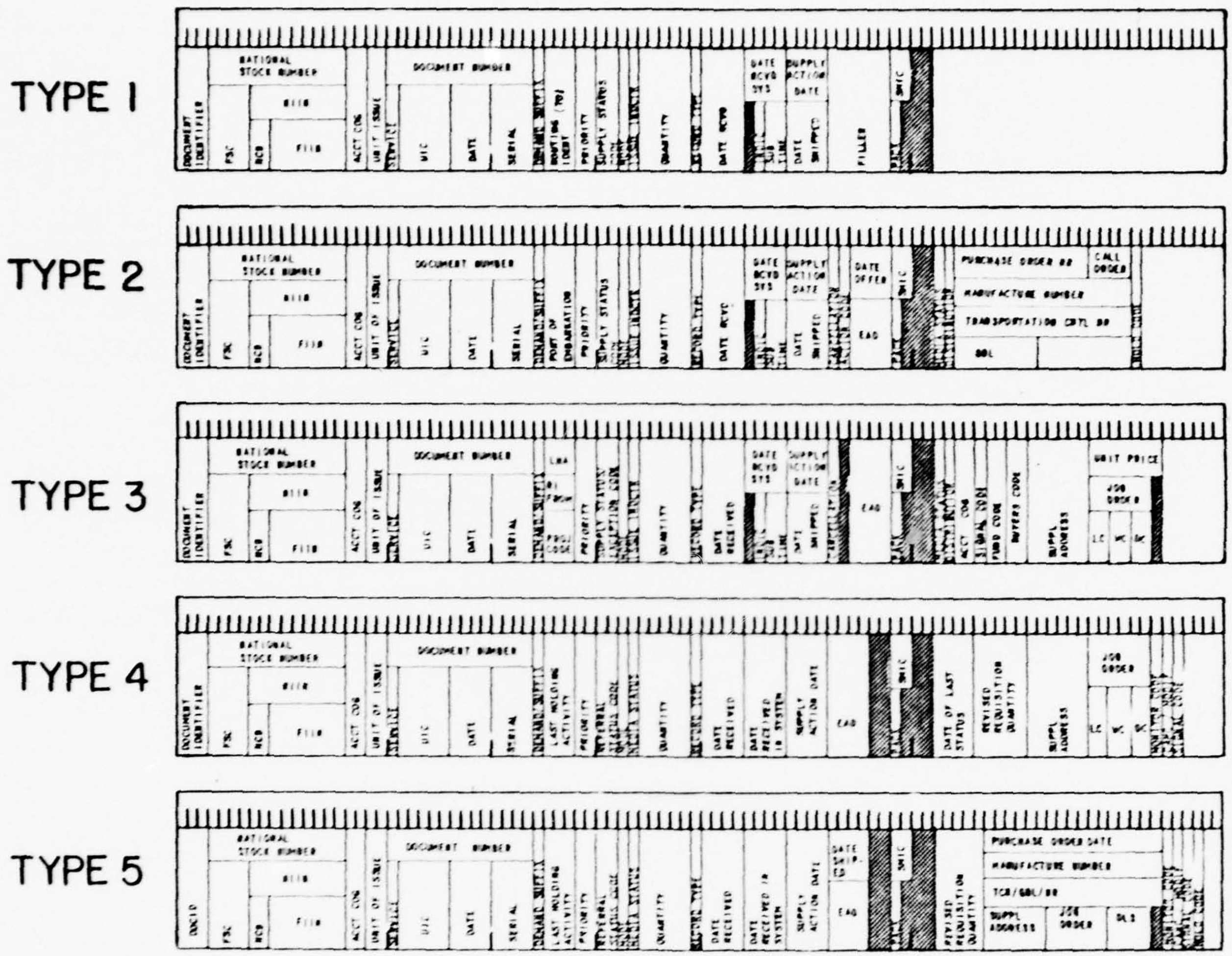


Figure 7 - HISTORICAL DEMAND RECORD FORMAT

2. Data Base Establishment

Eight standard labeled IBM tapes were obtained from NSC Oakland. These tapes were generated from the RDHF and they contained all material transactions from September 1, 1976 to August 30, 1977. Over two million records were on these tapes. The transactions encompassed local material issues, demands for material not stocked at NSC Oakland, inter-depot transfers of material, and local procurements. The customers creating the majority of these demands for material were located world wide and numbered over eight thousand.

As only data for local customers was desired, numerous extraction programs were developed. The resulting data base contained only issues from stock for local customers, including local procurements. Much of the purification (duplicate records were discovered) and extraction of this data was conducted with the assistance of N. B. Nelson, LCDR, SC, USN, a fellow student at the Naval Postgraduate School. Upon completion of this reduction approximately 600,000 records (four tapes) remained and it was from this base that the vessel data was developed.

3. Data Extraction

Those data elements actually extracted for further analysis were common to all file records and in the same data fields. Specifically, the data fields used were as follows: a. the document number's unit identification code (UIC) and date; b. the date received; c. the supply action date; e. the quantity; and f. the priority.

The Appendix B program, ANG$DATA, extracted those records from the local customer transactions data base which met the following conditions:

a. Only those records of the previously identified mobile customers were considered.

b. Of the above records, only those records which the supply status code indicated that material had been locally issued were actually extracted (supply status code BA).

Each data record which meet the above criteria, was also coded to facilitate the identity of its owner and the owner's ship class.

4. Sample Size

In most cases the entire data base was used in the determination of the simulation parameters. The quantity, submission time, and process time parameters (as described later in this chapter) were the only varibles in which a sample was intentionally taken. This action was due to the limited memory space available for the execution of the FORTRAN program ANG$Dat1 and to keep the requirements down to reasonable values so that the required data runs could be made. In another case (Issue Group One priorities) a smaller sample size resulted because its occurrance was very scarce.

Tchebycheff's Theorem of Inequality [12] was utilized to determine sample size because normality could not be assumed to describe the underlying population.

Since it was desired that the sample mean would be

within one fifth of a standard deviation of the true mean with a probability of at least 0.95, a sample size of 500 was selected whenever possible.

5. Data Reduction

The FORTRAN program which begins the data analysis required for the simulation model is ANG$DAT1, Appendix C. Numerous data arrays were developed for further analysis, as follows:

a. Total daily requisitions submitted by each customer were represented by a matrix (365x17). The 365 dimension is the day of the year the requisition was prepared, and the 17 dimension represents the seventeen vessels under consideration. Quantities within the matrix were the actual number of requisitions prepared on a specific day by a particular vessel (we will call this a requisition bundle) . Date differences for a given customer within this matrix will be called the "inter-preparation times" for the bundles shown.

b. From the quantity field of the first 500 requisitions per local customer another matrix (500x17) was developed. This was done because the data base was random by customer and the quantity was assumed to be independent of the ship's location and time. The 500 dimension in this data array corresponds to the size of the sample, and the seventeen dimension again represented those vessels under consideration. The actual data elements in the matrix were the quantities ordered per requisition.

c. Submission time data for bundles of requisitions was also considered independent of the vessel or its class, and thus only one sample of 500 inter-arrival times was

extracted by selecting every one-hundred and eightieth requisition. Its value was computed by subtracting the document's date of preparation from the date of the document's receipt. This action was considered appropriate since groups of requisitions were modeled, and it was assumed all requisitions ready for submission would be submitted together.

d. The process time for a requisition was modeled as being dependent on the Issue Group of the requisition. This parameter was computed by subtracting the document's receipt date from the document's ready for shipment date, and was arranged into a matrix(500x3). The 500 dimension was the sample size, and the three dimension represents the Issue Group. Individual data elements corresponded to process times per requisition priority by NSC Oakland.

6. Bundle Preparation Time

Appendix D, ANG$FHIS, is the FORTRAN program which differenced tthe document number dates as recorded in the inter-preparation time matrix and utilized the standard library routine HISTG to produce a listing of the relative frequencies of times' from one to nine days for each customer.

Analysis of this data revealed a significant similarity of the output by vessel class. Figures 8 and 9, and Table 3 illustrate this similarity. Note the small values for the standard deviations of the relative frequencies at the bottom of Table 3. Because the relative frequencies were so alike, the vessels were grouped by class in this and all other vessel dependent parameter evaluations.

Table No. 3. RELATIVE FREQUENCIES OF INTER-PREPARATION TIME

TIMES BETWEEN BUNDLE PREPARATIONS IN DAYS

AE	1	2	3	4	5	6	7	8	9
22	.51	.19	.14	.08	.06	.02			
24	.54	.15	.11	.09	.04	.02	.01	.02	.02
25	.42	.20	.10	.10	.05	.04	.05	.02	.02
26	.53	.18	.09	.09	.06	.00	.03	.02	.01
29	.53	.20	.11	.08	.03	.03	.00	.01	.01
32	.56	.13	.14	.07	.04	.02	.01	.01	
33	.46	.19	.08	.08	.08	.06	.02	.01	.02
35	.53	.16	.11	.10	.06	.02	.01	.00	.01
AVE	.516	.175	.112	.085	.053	.024	.014	.011	.002
ST.DE	.046	.026	.021	.010	.016	.018	.016	.008	.003

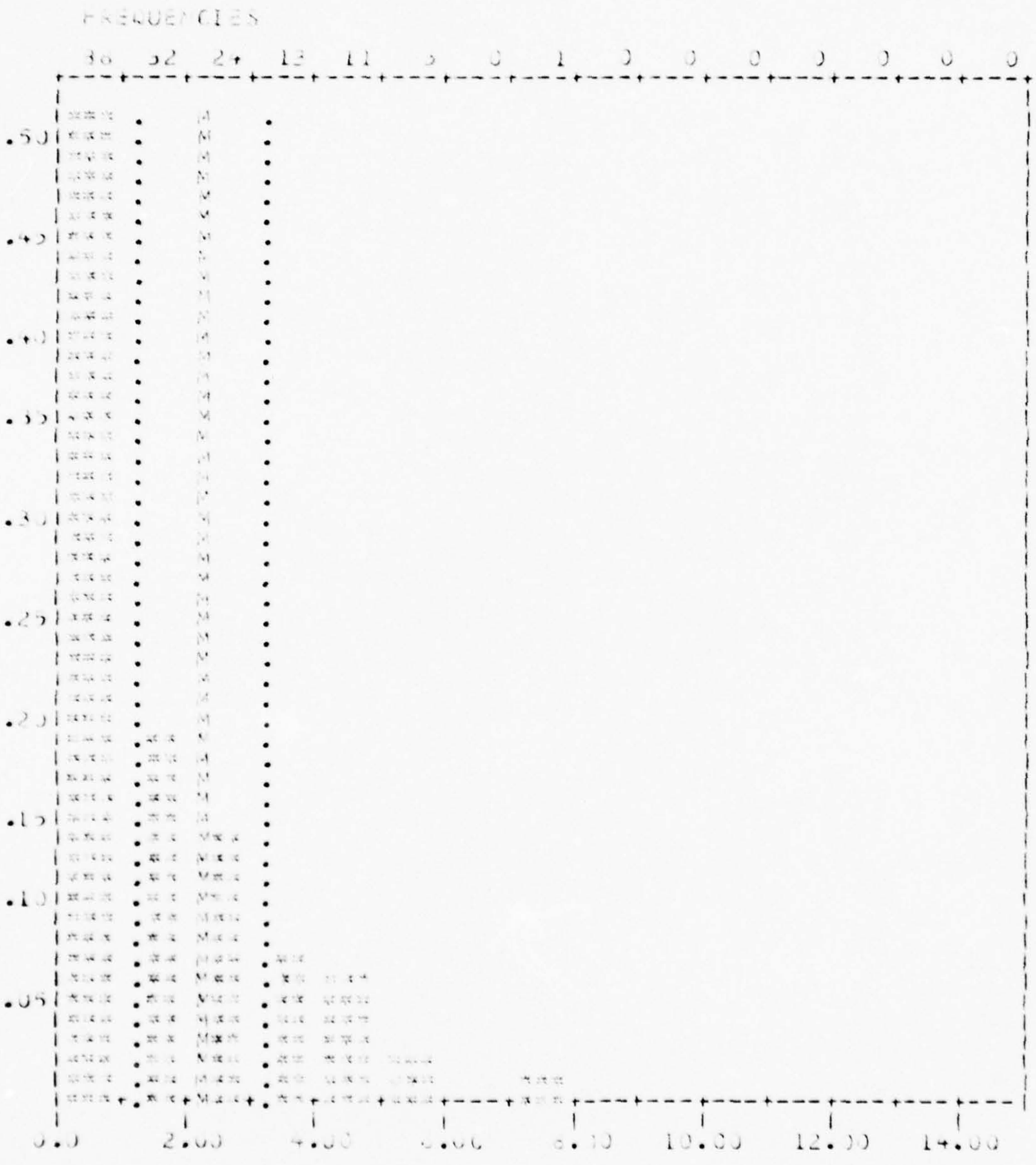


Figure 8 - AE 22 BUNDLE INTER-PREPARATION HISTOGRAM

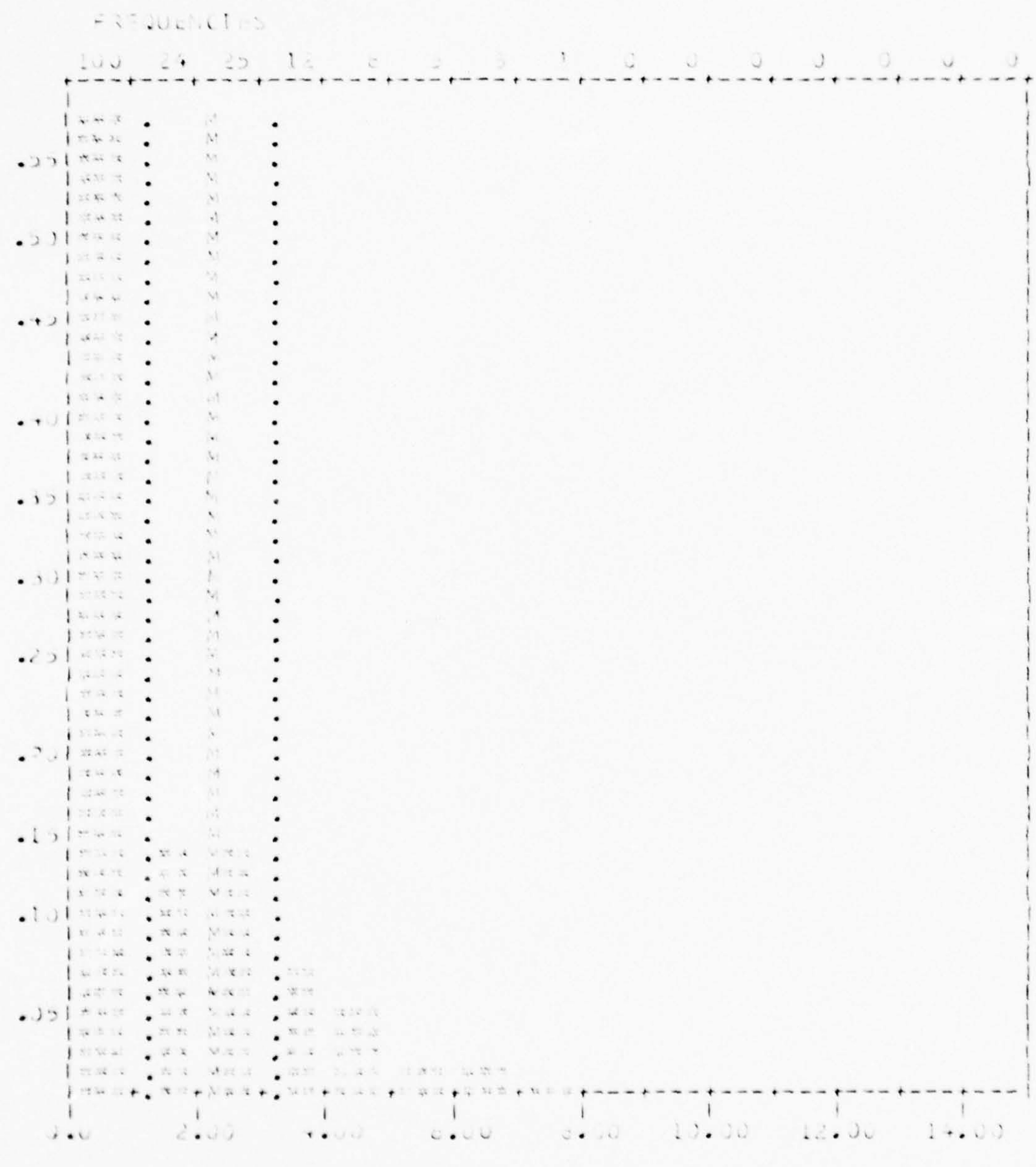


Figure 9 - AE 32 BUNDLE INTER-PREPARATION HISTOGRAM

Upon completion of the class pooling of the data several probabilistic distributions were examined for applicability. Since the histograms were exponentially shaped this was the first distribution tested. The inverse of the mean value was used as the exponential parameter. However, this hypothesis failed the Chi-square goodness of fit test at the five per cent level.

Next an attempt was made to fit a geometric distribution to the data. Inter-preparation times were measured in the data base by one day increments. Therefore, geometric parameters were established by assuming that if a bundle was prepared within one day, there were zero days in which a bundle was not prepared. We will denote P as the probability of a bundle being prepared in one day. However, if an actual bundle required two days to prepare, then we will assume that there was one day in which a failure occurred, i.e. no bundle preparation, and then a success. If a bundle required three days to prepare, we will assume there were two failures, i. e. day one and day two with no bundle preparations, and then a success; and so on. This results in a classical distribution with the following probability mass function:

$$f(X) = P(1-P)^{x} \text{ for } x = 0,1,2,...$$

where,

x = the number of "failures" prior to a success

P = the probability of a success

Unfortunately this distribution also failed to fit the data, although, it did provide a better chi-square statistic than did the exponential distribution.

A combination of two distributions was attempted next. The author considered this approach because there was a strong possibility that any single distribution would be overwhelmed by the inter-preparations of one day. The hypothetical probabilistic distribution was constructed as follows:

1. Inter-preparation data of one day was separately modeled. Therefore, the probability of a bundle preparation occurring within one day was equal to "P_1".

2. The remaining data was assumed to be geometric and the probability of preparing a bundle in two days, "P_2", was computed from the remainder of the data.

The detailed derivation of the above distribution follows:

$$f(X) = \begin{cases} P_1 & \text{for } x = 0 \\ CP_2(1 - P_2)^x & x = 1, 2, \ldots, \end{cases}$$

Where,

P_1 = probability of a bundle preparation during the first day

P_2 = probability of a bundle preparation in two days

$f(X)$ = probability density function

x = number of days with no bundle preparations

General solution for C:

$$P_1 + \sum_{x=1}^{n} CP_2(1 - P_2)^x = 1$$

$$CP_2(1 - P_2) \sum_{x=0}^{n} (1 - P_2) = 1 - P_1$$

$$\sum_{x=0}^{n} (1 - P_2)^x = 1/P_2 \text{ if } 0 < (1 - P_2) < 1$$

therefore

$$C = (1 - P_1)/(1 - P_2) .$$

The Chi-square statistic at the five per cent level of significance and with nine degrees of freedom is 16.92. One would accept this hypothesis if the computed statistic is less than or equal to 16.92. The computed statistics for AE class, AFS class, AOR class, MSO class, and AR class vessels were respectively 7.544, 10.917, 19.419, 11.450, and 38.57. The hypothesis that the distribution fits the data is acceptable in three of the five classes. The AR class, which had the largest error, was also the smallest in sample size (only one ship was in the sample) . There were three vessels in the other group which did not pass, however the smallest value was generated by the largest sample.

It is concluded that this developed distribution was an acceptable simulation tool for the determination of bundle inter-preparation times. The variable names AE.1UNDLE.INTER.ARRIVAL, AFS.1UNDLE.INTER.ARRIVAL, AOR.1UNDLE.INTER.ARRIVAL, MSO.1UNDLE.INTER.ARRIVAL, and AR.1UNDLE.INTER.ARRIVAL apply in the simulation.

7. Mail Time per Bundle

The inter-arrival time distribution for bundles sent by local vessels to NSC Oakland was modeled as being

influenced only by the US Postal Service and as such was independent of both the vessel class and the material requirements.

This distribution was tested using the Chi-Square goodness of fit test and was found to be exponential with a mean of 8.886 days at both the five per cent and the one percent levels of significance. It was assigned the variable name MAIL.TIME in the simulation.

8. Number of Requisitions per Bundle

All the following distributions developed and implimented in the simulation are empirical, except as noted.

Five empirical distributions, one for each class, were developed from the data to describe the number of requisitions per bundle. The following table lists the probabilities of falling in the ranges shown based on those distributions by ship class:

Table No. 4. PROBABILITIES OF REQUISITIONS PER BUNDLE

Class	Number of Requisitions							
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-
AE	.541	.172	.078	.062	.030	.035	.025	.029
AFS	.692	.126	.036	.032	.019	.012	.003	.024
AOR	.478	.162	.108	.075	.058	.038	.020	.041
AR	.170	.091	.125	.095	.098	.106	.071	.124
	Number of Requisitions							
	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-
MSO	.591	.203	.076	.025	.017	.030	.000	.034

Although ranges were used in the above table, all values utilized in the simulation were converted to integers. These parameters were modeled as random linear empirical distributions in the simulation. Their identification is AE•REQ•PER•BUNDLE, AFS•REQ•PER•BUNDLE, AOR•REQ•PER•BUNDLE, AR•REQ•PER•BUNDLE, and MSO•REQ•PER•BUNDLE respectively.

9. Requisition Priority

A probability distribution for material priorities was determined by calculating the percent of requisitions which were in Issue Group One (priority one through three), the percent which were in Issue Group Two (priority four through eight), and the percent which were in Issue Group

Three (priority nine through fifteen). It should be noted that the requisition priority was considered independent of both the individual ship and the ship class. Thus, only one distribution was developed for all vessels. This approach can be considered appropriate since all of these particular vessels operate under the same priority determination criteria. It was developed from the data as follows:

The issue Group One, requisitions of priorities 1 through 3, were tabulated and only 72 out of 94,434 cases occurred. It was therefore very unlikely that an Issue Group One event would be observed. In fact, this event would be realized only .08 of one per cent of the time.

Issue Group Two, priorities 4 through 8, requisitions were found to be more prevalent, being 14,157, and their probability of occurrence was computed to be .1499.

Issue Group Three, priorities 9 through 15, had the highest observed incidence with a probability of .8493.

The simulation variable for this parameter is REQ•PRIORITY.

10. Process Times

The requisition process time was modeled as being dependent on only the priority (Issue Group) of the requisition. This approach was considered reasonable because different Issue Groups are actually processed differently. The various picking documents for the material are expedited to the warehouse and are colored differently for high priority material (Issue Group One and Two).

The following distributions were developed by subtracting the date of document receipt at NSC Oakland from the date that the material was ready for shipment in the data base.

The Issue Group One requisition process time cumulative distribution was determined to be between 0.0 and 1.95 with probability .394, between 1.96 and 7.77 days with probability .423, and between 7.8 and 29 days with probability .183. It should be further noted that the number of usable data points was less than 72 for the following reasons; (1) the original number of data points in this Issue Group was only 72, (2) entries in the data base were discovered which showed that certain requisitions had been shipped prior to receipt of the requisition, (3) other date errors occurred; for example, several requisitions showed that over 300 days were used in the processing time. These types of errors also occurred in the other Issue Group data bases and were also ignored in the distribution computations.

The Issue Group Two process time cumulative distribution was also between zero and 1.2 days with probability .5, between 1.3 and 14.3 days with probability .42, and between 14.4 and 38 days with a .08 probability.

The process time for Issue Group Three requisitions was between zero and 1.2 days with probability .56, between 1.2 and 15.5 days with probability .395, and between 15.5 and 38 days with probability .045.

11. Quantity per Requisition

Since requisitions for material may be a request for more than one of an item , the appropriate field in the data

action date; e. the quantity; and f. the priority.

base was utilized to evaluate the process. It was assumed that the various quantities ordered per requistion would be dependent on the vessel class. Thus, five cumulative distributions were developed.

Those quantities expected for an AE class vessel were found to be between one and five with probability .608, between six and ten with probability .238, and between 11 and 160 with a .154 probability.

The other vessel class distributions were modeled with the same uniform ranges but differing probabilities. In the AFS class, the probabilities are .576, .171, and .253 respectively. The probabilities for the AOR class are .612, .161, and .227; for the MSO class .559, .143, and .298; and, for the AR class .496, .164, and .340 respectively.

12. Weight per Requisition

That data required for the parameter determination of this attribute was not available. However the author assumed a classical exponential distribution with an expected value of two pounds per each item. The mean weight per requisition generated by this simulation was 193 pounds. Hernandez and Gallitz [8] stated that 28,586,168 pounds (fiscal year 1975), and 26,805,662 pounds (fiscal year 1976) of material were delivered by the BALD system. This equates to an average of 73 pounds per requistion and 69 pounds per requisition respectively (assuming that there was not a significent change in the total number of requisitions per year from 1978). Observations by this author at the BALD shipping and delivery points revealed that it was uncommon to witness a full truck load shipped. In fact most shipments were only one pallet level high, yet statistically

full truckload weights were recorded on the shipment records. Because of this, it was suspected that the weights [12] are overstated.

It is therefore concluded that the parameter of two pounds chosen for the mean of the distribution was too large. Thus, the actual number of shipments made was selected at a proxy measure of effectiveness for this variable. Resultant outputs from this assumption have not been included in the results section of this thesis.

III. SIMULATION

A. GENERAL

SIMSCRIPT II.5 is a language particularly suited to discrete-event step simulations. It has been designed to facilitate the simulation of large complex systems with a minimum of effort in programming, designing, and testing the model.

It is not the intent of this paper to discuss the details of this unique programming language, and anyone desiring to examine it in depth should refer to references 9 and 13 .

B. PROGRAM DESCRIPTION

The modeling of that segment of the BALD system impacted by the random movement of vessels between various ports was developed by considering two major series of events.

First, the vessel movements were modeled using the previously discussed parameters and techniques. This series of events deals primarily with vessel movement impacts on the ultimate destination of shipped material. This series also removes material from a "old" shipping queue and relocates the material in the appropriate "new" shipping queue corresponding to the vessel's new location.

The remaining series of events recreates the material processing involved. Their logical functional order commences with the preparation of a group of material requirements. Next, this group of material requirements arrives at NSC Oakland and is reduced to its individual material requests. These requisitions then are scheduled through the material processing system and a shipment availability time is determined. The final events collect statistics and determine the frequency and the destination of the various shipments.

1. Detailed Analysis

The preamble defines various system variables, events, and entities. Actual execution commences with the main program. It first assigns user defined values to the permanent entities (ships). This segment then reads all the program decision variable distributions, schedules an initial port change and bundle preparation for each vessel, schedules the initial shipments to each port, and schedules the two one-time events, Stop.simulation and Equilibrium.

From this time on the SIMSCRIPT event step simulation time scheduling routine takes over. Events will occur as determined by the scheduling parameters throughout the program. The specific events are detailed below.

Bndle.preparation: This event schedules the next bundle preparation for each vessel based on the class of the vessel. It then determines the the value of the number.of.requisitions(bundle) and then schedules an arrival time at NSC Oakland.

Arrival.of.bundle: The temporary entities, requisitions, are created in this event. They are assigned

all their attributes (priority, quantity, and customer) based on the previously discussed parameters. Then a Ready.for.shipment event is scheduled based on the requisition's priority. Finally, the temporary entity bundle is destroyed to release memory space in the computer.

Change.location: The vessel's new location is determined based on ship class markov chains. Statistics are accumulated to record both the number of location changes per vessel and per vessel class. At this time, if this vessel has any material in one of the port shipping queues, it is removed and put in the newly determined port shipping queue. The system statistics are also appropriately adjusted. Finally, the next port change for this vessel is scheduled based on the vessels current location.

Ready.for.shipment: The shipping location is first determined, and the requisition is filed in the appropriate shipping queue. This event also may schedule an immediate shipment of material depending on the decision rules involved.

Shipment.to: This event computes the majority of the statistics. It also contains all decision rules on shipping stratagy. Upon completion of this event the next shipment to is scheduled for this port.

2. Seeds

Since the pseudo random number generator was seed dependent, ten seeds were initially selected and program runs were made to identify equilibrium conditions and reverify the simulation's validity. The seeds were selected at least 800,000 numbers apart to preclude overlapping of

33

the number stream.

In order to to evaluate the stability of the measures of effectiveness as related to seed changes, Ten runs (one run per seed) were made with each decision rule. It was noted that in some instances the SIMSCRIPT program exceeded the 430,000 bytes allocated . Since the variations in the measures of effectiveness (average wait time and the number of shipments) were minimal, it was not considered necessary to rerun these programs, see Appendix H.

3. Equilibrium Determination

The equilibrium or steady-state of the system is defined as a condition of regularity of stability in which opposing influences are balanced. Thus, it is assumed that for this model there is a limiting probability distribution of the responses that is charactertistic of the system. This state was determined by a method stated by Conway[5]. Specifically, the series of measurements were truncated until the first of the series was neither the maximum nor the minimum of the remaining set.

The number of requisitions shipped to each port was one of the measurements evaluated in the above manner. The determining port was N.A.S. Alameda and the time to steady-state was two weeks. Inadvertently, the number of shipment's variable was not adjusted for this two week period and a lack of time precluded the rerunning of this computer simulation. Thus, this measure of effectiveness was accumulated over a fifty-four week interval.

A determination of the equilibrium condition for the ship movements was not made. The initial starting conditions for the simulation were chosen so that they were

typical of the steady-state condition. For example, all vessels were initially located at factual locations, rather than positioning them arbitrarily and then determining the steady-state condition.

4. Shipping Strategies

Four shipping decision rules were analysed as follows: a. CASE I - all material ready for shipment is shipped daily; b. CASE II - all material ready for shipment is shipped weekly; c. CASE III - in addition to CASE II actions, Issue Group 1 material (with all other destined for the same location) is shipped immediately; d. CASE IV - in addition to the CASE III decision rules, Issue Group 2 material (again with all other material in the appropriate queue) is shipped once a day.

Appendices E, F, and G contain those events which were modified for each decision rule.

5. Measures of Effectiveness

Two measures of effectiveness were selected. First, the amount of time requisitions were waiting to be shipped was chosed as a measure of customer service. Second, the actual number of shipments released was selected as an evaluation of the cost of the chosen stratagy. The total number of shipments is considered a proxy variable for shipping costs.

C. RESULTS

The outputs from the forty program runs have been tabulated by each decision rule and are presented in Appendix H. The logically expected results in the mean waiting times was observed. Mean waiting times of .48 to .53 were observed when shipments were daily. Under weekly shipping rules the mean waiting times were 3.41 to 3.61 days.

Since program runs were seed dependent and a comparison of decision rules was desired, only those runs in which all results were obtained for all cases will be examined here. These runs were numbers 2, 3, 5, 6, and 8 as found in Appendix H. Data from these runs were then averaged by Issue Group within each decision rule (case). Weighted averages were then computed per case by assigning weights which were representative of each Issue Group's probability of occurrance. The values used were .0008 (Issue Group One), .1499 (Issue Group Two), and, .8493 (Issue Group Three). The results of these computations represent five years worth of simulation per case and are presented in Table 5.

Table No. 5. AVERAGED RESULTS

CASE	ISSUE GROUP	MEAN TIME	STD DEV	MAX TIME	MIN TIME	TOTAL TRIPS
I	1	.49	.29	.99	.01	
	2	.50	.29	1.00	.00	
	3	.50	.29	1.00	.00	2076
	Ave	.50	.29	1.00	.00	
II	1	3.48	1.89	6.92	.14	
	2	3.52	2.01	7.00	.00	
	3	3.51	2.02	7.00	.00	319
	Ave	3.51	2.02	7.00	.00	
III	1	.00	.00	.00	.00	
	2	2.93	1.99	7.00	.00	
	3	2.91	1.99	7.00	.00	387
	Ave	2.91	1.99	7.00	.00	
IV	1	.00	.00	.00	.00	
	2	.49	.29	1.00	.00	
	3	.52	.38	6.93	.00	1853
	Ave	.52	.37	6.04	.00	

IV. DISCUSSION AND CONCLUSIONS

A. DISCUSSION

It is noteworthy that minor variations in the average waiting times have significant impact in the total number of shipments. Increasing the waiting time per shipment from .5 to 3.5 days has the effect of reducing the number of shipments from an average of 2076 to an average of 319 trips per fifty-four weeks. or a 6.6-fold decrease.

However, adjusting the weekly shipments by shipping Issue Group One material immediately (CASE III) reduced their waiting times to zero, yet did not significantly increase the total number of shipments experienced. In fact, they only increased from 319 to 387 per 54 weeks. This is not an unexpected result since there was only a .08 per cent chance of a vessel generating an Issue Group One shipping requirement.

Finally, CASE IV decision parameters resulted in almost the same number of shipments as when daily shipments were made. The average number observed for 54 weeks was 1853, on the average only 263 shipments less per year.

The weighted averages of each case were used to construct Figure 10. The dependent variable was the mean wait time in days and the independent variable was the number of shipments made in fifty-four weeks. The curve was constructed assuming that the unknown function was

"hyperbolically" shaped. This assumption was supported by the observation that as the number of shipments approach infinity the average waiting time would be expected to become zero, and as the number of shipments approach zero the average waiting time would be expected to become infinite.

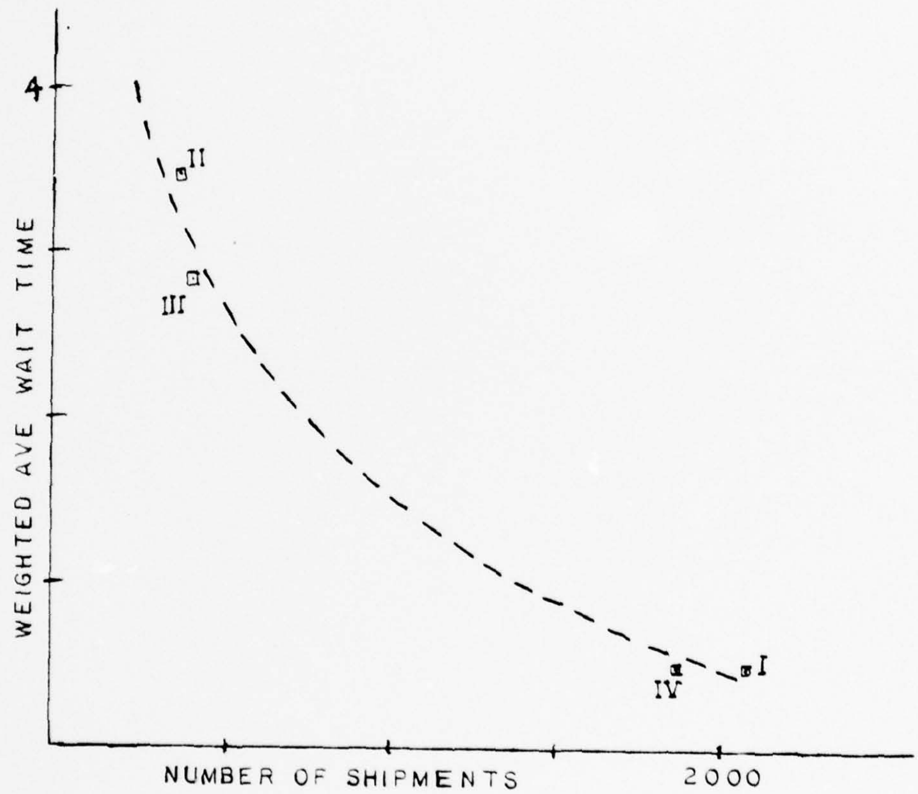


Figure 10 - SHIPMENTS VS WAITING TIME

The curve of Figure 10 provides a practical tool for a decision maker. If an objective function is known (such as a decision maker's relationship between the relative importance of waiting times and the number of shipments), the "optimum" number of shipments could be determined. For example, if it was decided that the number of shipments was twice as important as waiting times, an objective function could be constructed as follows: total cost = (cost constant) x (waiting time) + (cost constant) x (2) x (number of shipments). The appropriate cost constants would have to be selected to convert the variables to dollars. This objective function could then be used with the curve to determine an "optimal" solution. However, this solution should not be attempted until additional simulations are run to verify the midrange of the curve.

B. CONCLUSIONS

In view of the simulation results, it would appear that actual modification of the current shipping parameters may yield substantial transportation savings. However, because such parameters as the weight and volume of the larger shipments were not evaluated, delaying a shipment beyond the time when a full truck load is ready for shipping would not be expected to result in any savings.

It is recommended that follow-on modeling in this area be conducted. The weight and volume parameters should be identified and decision rules should be modified to include maximum and or minimum weight/volume shipping restrictions. Additional shipping strategies (cases) also need to be proposed and analyzed (for example, allow Issue Group II's to be shipped every other day, every third day, etc.) to

fill in the middle of the curve of Figure 10. Finally, the simplifing assumptions of the model presented in this paper need to be critically reviewed and any which seriously violate reality should be replaced by more realistic ones and the analysis repeated.

APPENDIX A

SHIPS INFORMATION BULLETIN

NAVSUPPACT-30 SHIPS INFORMATION - 765-6661
0900 UNIFORM PORT SERVICES OFFICE
18-24 APR 78 NAVAL SUPPORT ACTIVITY
{TUE-MON} TREASURE ISLAND
SAN FRANCISCO, CALIFORNIA 94130
AREA CODE 415 UNLESS OTHERWISE INDICATED

SUNRISE	SUNSET
180530U	181848U
190529U	191848U
200528U	201849U
210526U	211850U
220525U	221851U
230524U	231852U
240522U	241853U

SOPA SFRAN, COMSERVGRU ONE, CAPT E.J. MESSERE, USN
SOPA SUBAREA SOUTH, COMSERVGRU ONE, CAPT E.J. MESSERE, USN
SOPA SUBAREA NORTH, COMSERVRON THREE, CAPT C.W. O'REILLY, USN

COMCARGRU THREE - 869-2131
COMSCPAC - 466-6316
COMSERVGRU ONE - 466-5812
COMSERVRON THREE - 707-646-3538

SHIPS PRESENT SAN FRANCISCO BAY AREA

SHIP	HULL	BERTH	PHONE
BLAND	T-AK-277	NSC	466-5950
BROSTROM	T-AK-255	NSC	466-5710
CARPENTER	DD-825	NAS - ETD 4/24/78 - [illegible]	869-3037
COOK ETC 5/17/78	FF-1083	TRIPLE A SHPYD	822-2120
EXCEL	MSO-439	TODDS SHPYD ALAMEDA	523-0321
FANNING ETC 4/11/78	FF-1076	TRIPLE A SHPYD	822-2360
FLINT	AE-32	NAS - ETD 4/24 - WPNSTA	869-3766
GALLANT ETC 5/12/78	MSO-489	PACIFIC DRYDOCK	893-1092
HADDOCK ETC 10/12/78	SSN-621	MINSY	707-646-4370
HALEAKALA	AE-25	WPNSTA	671-5004
HECTOR	AR-7	NAS	869-3970
HEPBURN ETC 5/13/78	FF-1055	TRIPLE A SHPYD	822-8711
KANSAS CITY	AOR-3	NAS - ETD 4/24/78 - SD	869-2020
KISKA	AE-35	NAS - ETD 4/24/78 - SD	869-3650
MAUNA KEA	AE-22	TODDS SHPYD ALAMEDA	523-0321
MOUNT HOOD	AE-29	NAS	869-4722
MYER	T-ARC-6	NSC	466-5001
PERMIT	SSN-595	MINSY	707-646-3264
ROBERT E. LEE ETC 6/2/78	SSBN-601	MINSY	707-646-3432
SEAWOLF	SSN-575	MINSY	707-646-4197
SHASTA	AE-33	TODDS SHPYD ALAMEDA	865-0445
TAUTOG	SSN-639	MINSY	707-646-4150
VANGUARD	T-AFM-19	NSC	466-6398
WABASH ETC 5/19/78	AOR-5	TODDS SHPYD ALAMEDA	523-0321
NIAGARA FALLS	AFS 3	NAS (ETA 4/21/78)	

APPENDIX B

FORTRAN PROGRAM ANG DATA

```
//ANG$DATA JOB (2427,0331,RZ81),'EXT=2740',TIME=75
// EXEC FORTCLG
//FORT.SYSIN DD *
      INTEGER*2 ISTAT,IBA
      DATA IBA/'BA'/, INR1/0/, INR2/0/
      DIMENSION DATA1(10),DATA2(13)
 10   READ(10,100,END = 999) DATA1,ISTAT,DATA2,IUIC,II,ICLUS
100   FORMAT(10A4,2A2,12A4,I3,I3,I2)
      INR1 = INR1 + 1
      IF(ICLUS .NE.10 .OR. ISTAT .NE. IBA) GO TO 10
      INR2 = INR2 + 1
      IF(IUIC .NE. 18) GO TO 20
      IUCI = 101
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
20    IF(IUIC .NE. 29) GO TO 22
      IUIC = 102
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
22    IF(IUIC .NE. 37) GO TO 24
      IUIC = 103
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
24    IF(IUIC .NE. 28) GO TO 26
      IUIC = 104
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
26    IF(IUIC .NE. 25) GO TO 28
      IUIC =105
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
28    IF(IUIC .NE. 24) GO TO 30
      IUIC = 106
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
30    IF(IUIC .NE. 15) GO TO 32
      IUIC = 107
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
32    IF(IUIC .NE. 23) GO TO 34
      IUIC = 108
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
34    IF(IUIC .NE. 9) GO TO 36
      IUIC = 209
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
36    IF(IUIC .NE. 8) GO TO 38
      IUIC = 210
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
```

```
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
38    IF(IUIC .NE. 14) GO TO 40
      IUIC = 211
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
40    IF(IUIC .NE. 21) GO TO 42
      IUIC = 312
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
42    IF(IUIC .NE. 19) GO TO 44
      IUIC = 313
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
44    IF(IUIC .NE. 11) GO TO 46
      IUIC = 314
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
46    IF(IUIC .NE. 46) GO TO 48
      IUIC = 415
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
48    IF(IUIC .NE. 45) GO TO 50
      IUIC = 416
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
50    IF(IUIC .NE. 5) GO TO 10
      IUIC = 517
      WRITE(20,100)DATA1,ISTAT,DATA2,IUIC,II,ICLUS
      IF(INR2.LE.1000)WRITE(30,100)DATA1,ISTAT,DATA2,IUIC,II
     .ICLUS
      GO TO 10
999   WRITE(6,200)INR1,INR2
200   FORMAT(1X,'TOTAL RECORDS = ',I7,10X,'TOTAL BA RECORDS
     .= ',I7)
      END FILE 20
      END FILE 30
      STOP
      END
//GO.FT10F001 DD UNIT=3400-3,VOL=SER=NPS707,DISP=(OLD,KEEP),
// LABEL=(1,SL,,IN),DSN=S2390.LOC.DLV.SORTED.UIC.V
//GO.FT20F001 DD DSN=S2427.LOC.SHIP.BA,VOL=SER=NPS715,
//   DISP=(OLD,KEEP),
// UNIT=3400-3,LABEL=(1,SL,,OUT),DCB=(RECFM=FB,LRECL=100,)
//,BLKSIZE=8000)
//GO.FT30F001 DD DSN=S2427.LOC.SHIP.BA,LABEL=EXPDT=79365,
// SPACE=(2000,(55,5)),VOLUME=SER=DUFFY,DISP=(OLD,KEEP),
//UNIT=2314
```

APPENDIX C

FORTRAN PROGRAM ANG DAT1

```
THE FOLLOWING PROGRAM EXTRACTS THAT DATA NECESSARY
FOR THE DETERMINATION OF THE MATERIAL PARAMETERS OF
THE SIMULATION.
//ANG$DAT1 JOB (2427,0331,RZ81),'EXT=2740',TIME=60
// EXEC FORTCLG
//FORT.SYSIN DD *
       REAL*8 UICLOC
       DIMENSION NUMB(367,18), IQUAN(500,18),MAILT(500).
      .,IGROUP(4),UICLOC(18),NN(17),PGROUP(4),MAPRI(500,3)
      .IPROC(500,4)
       DATA NUMB/6606*0/,IQUAN/9000*0/,MAILT/500*0/.
      .,IGROUP/4*0/,IPRT/0/,          I1/0/,I2/0/,I3/0/,I4/0/,C
      .K/0/,A/1.0/,NN/17*0/,IFLG1/0/,IFLG2/0/,MAPRI/1500*0/.
      .IPROC/2000*0/
       CALL SETIME
10     READ(10,100,END=26)IDATE1,IPRI,IQN,IDATE2,IDATE3,IUIC
       IF(IPRI .EQ. 0) GO TO 10
       IF(IUIC .EQ. 18)IUIC = 01
       IF(IPRT .EQ. 100)WRITE(6,100) IDATE1,IPRI,IQN,IDATE2,
      .IDATE3,IUIC
100    FORMAT(27X,I3,8X,I2,4X,I5,2X,I3,5X,I3,31X,I2)
C
C
       IF(IDATE1 .GT. IDATE2) IDATE2 = IDATE2 + 365
       IF(IDATE2 .GT. IDATE3) IDATE3 = IDATE3 + 365
       NUMB(IDATE1,IUIC) = NUMB(IDATE1,IUIC) + 1
C
C
       IF(IPRI .GT. 3) GO TO 20
       IGROUP(1) = IGROUP(1) + 1
         I1 = I1 + 1
         IF(I1 .LE. 500) IPROC(I1,1) = IDATE3 - IDATE2
       IF(I1 .LE. 500) MAPRI(I1,1) = IDATE2 - IDATE1
20     IF(IPRI .LT. 4 .OR. IPRI .GT. 8) GO TO 22
       IGROUP(2) = IGROUP(2) + 1
       IF(IFLG1 .LT. 10) GO TO 21
       IFLG1 = C
         I2 = I2 + 1
         IF(I2 .LE. 500) IPROC(I2,2) = IDATE3 - IDATE2
       IF(I2 .LE. 500) MAPRI(I2,2) = IDATE2 - IDATE1
21     IFLG1 = IFLG1 + 1
22     IF(IPRI .LT. 9) GO TO 24
       IGROUP(3) = IGROUP(3) + 1
       IF(IFLG2 .LT. 90) GO TO 23
       IFLG2 = 0
         I3 = I3 + 1
         IF(I3 .LE. 500) IPROC(I3,3) = IDATE3 - IDATE2
       IF(I3 .LE. 500) MAPRI(I3,3) = IDATE2 - IDATE1
23     IFLG2 = IFLG2 + 1
24     CONTINUE
       NN(IUIC) = NN(IUIC) + 1
       K =NN(IUIC)
       IF(K .LE. 500) IQUAN(K,IUIC) =IQN
C
C
       COUNT1 = COUNT1 + 1.0
       IF(COUNT1/180.0 .NE. A) GO TO 10
         A = A + 1
         I4 = FIX(A)
```

```
          IF(A .LE. 500) MAILT(I4) = IDATE2 - IDATE1
         GO TO 10
26       CONTINUE
         IGROUP(1) = I1
         CALL GETIME(IET)
         SECS= IET* 0.000026
         WRITE (6,1111) SECS
1111     FORMAT(F16.12)
         IGROUP(4) =IGROUP(1) + IGROUP(2) + IGROUP(3)
         PGROUP(1) = FLOAT(IGROUP(1))/FLOAT(IGROUP(4))*100
         PGROUP(2) = FLOAT(IGROUP(2))/FLOAT(IGROUP(4))*100
         PGROUP(3) = FLOAT(IGROUP(3))/FLOAT(IGROUP(4))*100
         DO 32 J=1,17
         DO 28 I=244,365
         IF (NUMB(I,J) .NE. 0) WRITE (20,110) I,J,NUMB(I,J)
    110  FORMAT (2I3,I6)
     28  CONTINUE
         DO 30 I=1,243
         IF (NUMB(I,J) .NE. 0) WRITE (20,110) I,J,NUMB(I,J)
     30  CONTINUE
     32  CONTINUE
         END FILE 20
C
C        PRINT MATRIX 9 COLUMNS AT A TIME
         READ(5,115)UICLOC
115      FORMAT(A6)
         JEND = 17
         NEND = JEND - 1
C
         DO 34 N = 1,NEND,9
         NIEND = N + 8
           WRITE(6,122)
122      FORMAT('1',15X,'FREQUENCY OF REQNS BY SHIP'//)
         WRITE(6,120) (UICLOC(NI),NI=N,NIEND)
120      FORMAT(11X,9(A6,2X)/)
         WRITE(6,130) (NJ,(NUMB(NJ,NK),NK=N,NIEND),NJ=244,365)
         WRITE(6,130) (NJ,(NUMB(NJ,NK),NK=N,NIEND),NJ=1,243)
         WRITE(6,124)
124      FORMAT('1',15X,'QUANTITY PER REQN BY SHIP'//)
         WRITE(6,120) (UICLOC(NI),NI=N,NIEND)
         WRITE(6,130) (NJ,( IQUAN(NJ,NK),NK=N,NIEND),NJ=1,500)
130      FORMAT(I6,2X,I6,2X,I6,2X,I6,2X,I6,2X,I6,2X,I6,2X,I6,2X
        .I6,2X,I6,2X)
 34      CONTINUE
         WRITE(21,132)((J, IQUAN(I,J),I=1,500),J=1,17)
132      FORMAT (I2,I6)
         WRITE(6,131)
131      FORMAT(////)
         WRITE(6,134)(I,IGROUP(I),PGROUP(I),I=1,3)
134      FORMAT(10X,'ISSUE GROUP ',I1,' TOTAL NR OF REQ:',T55,
        .I5,T65,'PERCENT:',2X,F5.2)
         WRITE(6,135)
135      FORMAT('1',10X,'NSC ISSUE/SHIP TIME BY IGRP AND REQN
        .MAIL TIME'//)
         READ(5,115)(UICLOC(I),I=1,4)
         WRITE(6,136) (UICLOC(I),I=1,4)
136      FORMAT(20X,3(A6,2X),10X,A6)
            WRITE(6,150)(I,(IPROC(I,J),J=1,3),MAILT(I),I=1,500)
150      FORMAT(12X,I7,I6,2X,I6,2X,I6,2X,10X,I6)
         WRITE(22,132)((J,IPROC(I,J),J=1,3),I=1,500)
         WRITE(23,153)(MAILT(I),I=1,500)
153      FORMAT(I6)
         WRITE(7,156)((J,MAPRI(I,J),I = 1,500),J = 1,3)
156      FORMAT(20(I1,I3))
C
         CALL GETIME(IET)
         SECS= IET * 0.000026
         WRITE (6,1111) SECS
         STOP
         DEBUG SUBCHK
         END
//GO.FT10F001 DD DSN=S2427.LCC.SHIP.BA,VOL=SER=NPS715,
```

```
//   DISP=(OLD,KEEP),
// UNIT=3400-3,LABEL=(1,SL,,IN)
//GO.FT20F001 DD LABEL=EXPDT=79365,UNIT=2314,VOL=SER=DUFFY,
// DSN=S2427.L.SHIP.BA.BUNDLE.FREQ,
// DCB=(RECFM=FB,LRECL=12,BLKSIZE=6000),SPACE=(6000,(14,5)),
// DISP=(OLD,KEEP)
//GO.FT21F001 DD LABEL=EXPDT=79365,UNIT=2314,VOL=SER=DUFFY,
// DSN=S2427.L.SHIP.BA.QUAN.PER.REQN,
// DCB=(RECFM=FB,LRECL=8,BLKSIZE=6400),SPACE=(6400,(12,5)),
// DISP=(OLD,KEEP)
//GO.FT22F001 DD LABEL=EXPDT=79365,UNIT=2314,VOL=SER=DUFFY,
// DSN=S2427.L.SHIP.BA.PROCESS.TIME,
// DCB=(RECFM=FB,LRECL=8,BLKSIZE=6400),SPACE=(6400,(2,5)),
// DISP=(OLD,KEEP)
//GO.FT23F001 DD LABEL=EXPDT=79365,UNIT=2314,VOL=SER=DUFFY,
// DSN=S2427.L.SHIP.BA.MAIL.TIME,
// DCB=(RECFM=FB,LRECL=6,BLKSIZE=3000),SPACE=(3000,(1,5)),
// DISP=(OLD,KEEP)
//GO.SYSIN DD *
AE 1
AE 2
AE 3
AE 4
AE 5
AE 6
AE 7
AE 8
AFS 9
AFS 10
AFS 11
AOR 12
AOR 13
AOR 14
MSO 15
MSO 16
AR 7
DUMMY
IGRP 1
IGRP 2
IGRP 3
  MAIL
```

APPENDIX D

SIMSCRIPT PROGRAM ANG SIM

```
PREAMBLE
''
VERIABLE DEFINITION INFORMATION FOLLOWS
''
GENERATE LIST ROUTINES
''
THE NEXT 14 STATEMENTS DECLARE THE ENTITIES
AND THEIR ATTRIBUTES
''
PERMANENT ENTITIES
     EVERY SHIP HAS A LOCATION , A TYPE ,
     A T.SHIPPED, A T.CHANGE  AND MAY
     BELONG TO A SHIP.QUEUE
     EVERY PORT OWNS A SHIP.QUEUE AND A SHIPPING.QUEUE
     AND HAS A WT.SHIPPED AND A VOL.SHIPPED.
      A WT.FINAL.SHIPPED,
     A VOL.FINAL.SHIPPED, A TOT.REQ

TEMPORARY ENTITIES
     EVERY BUNDLE HAS A SORCE, A NUMBER.OF.REQUISITIONS
     EVERY REQUISITION HAS AN (OWNER(1/4),PRIORITY(2/4).
QUANTITY(17-32)),
               A WEIGHT, A VOLUME, A TIME.READY.FOR.SHIP
     AND MAY BELONG TO A SHIPPING.QUEUE

''
THE NEXT STATEMENT NOTIFIES THE COMPLIER THAT
EVENT NOTICES FOLLOW RATHER THAN ENTITIES
''
EVENT NOTICES INCLUDE  STOP.SIMULATION AND EQUILIBRIUM
''
THESE STATEMENTS ESTABLISH FIVE-WORD RECORDS
''
     EVERY  BNDLE.PREPARATION HAS A BOAT
     EVERY ARRIVAL.OF.BUNDLE HAS A ITEM
     EVERY READY.FOR.SHIPMENT HAS A ORDER
     EVERY CHANGE.LOCATION HAS A TUG
     EVERY SHIPMENT.TO HAS A PLACE
''
THE NEXT STATEMENT IDENTIFIES THE PROCESSING
PRIORITIES IN  THE PROGRAM
''
PRIORITY ORDER IS  BNDLE.PREPARATION, ARRIVAL.OF.BUNDLE,
READY.FOR.SHIPMENT, CHANGE.LOCATION, SHIPMENT.TO,
STOP.SIMULATION
''
THE FOLLOWING LINES ESTABLISHES POINTERS WHICH
ALLOWS THE SYSTEM TO OWN SETS.
THE FOLLOWING 57 LINES ARE THOSE SYSTEM PARAMETERS
WHICH THE SIMULATION UTILIZES
''
THE SYSTEM HAS A 1.WAIT.TIME,A 2.WAIT.TIME, A 3.WAIT.TIME,
 A SAN.FRAN.SHIP.INTER.DEPARTURE RANDOM STEP VARIABLE,
     A BETH.STL.SHIP.INTER.DEPARTURE RANDOM STEP VARIABLE,
     A AE.1UNDLE.INTER.ARRIVAL RANDOM STEP VARIABLE,
     A AFS.1UNDLE.INTER.ARRIVAL RANDOM STEP VARIABLE,
     A ADR.1UNDLE.INTER.ARRIVAL RANDOM STEP VARIABLE,
     A MSC.1UNDLE.INTER.ARRIVAL RANDOM STEP VARIABLE,
     A AF.1UNDLE.INTER.ARRIVAL RANDOM STEP VARIABLE,
```

```
A AE.ALAM.PORT.CHANGE RANDOM STEP VARIABLE,
A AE.MARE.ISL.PORT.CHANGE RANDOM STEP VARIABLE,
A AE.WEAP.STA.PORT.CHANGE RANDOM STEP VARIABLE,
A AE.NSC.OAK.PORT.CHANGE RANDOM STEP VARIABLE,
A AE.SAN.FRAN.PORT.CHANGE RANDOM STEP VARIABLE,
A AE.TODD.PORT.CHANGE RANDOM STEP VARIABLE,
A AE.BETH.STL.PORT.CHANGE RANDOM STEP VARIABLE,
A AE.DEPLOY RANDOM STEP VARIABLE,
A AOR.ALAM.PORT.CHANGE RANDOM STEP VARIABLE,
A AOR.NSC.OAK.PORT.CHANGE RANDOM STEP VARIABLE,
A AOR.TODD.PORT.CHANGE RANDOM STEP VARIABLE,
A AOR.BETH.PORT.CHANGE RANDOM STEP VARIABLE,
A AOR.DEPLOY RANDOM STEP VARIABLE,
A AFS.ALAM.PORT.CHANGE RANDOM STEP VARIABLE,
A AFS.NSC.OAK.PORT.CHANGE RANDOM STEP VARIABLE,
A ASF.TODD.PORT.CHANGE RANDOM STEP VARIABLE,
A AFS.TRIP.A.PORT.CHANGE RANDOM STEP VARIABLE,
A AFS.DEPLOY RANDOM STEP VARIABLE,
A AR.ALAM.PORT.CHANGE RANDOM STEP VARIABLE,
A AR.MARE.ISL.PORT.CHANGE RANDOM STEP VARIABLE,
A AR.NSC.OAK.PORT.CHANGE RANDOM STEP VARIABLE,
A AR.DEPLOY RANDOM STEP VARIABLE THE SYSTEM HAS
A MSO.ALAM.PORT.CHANGE RANDOM STEP VARIABLE,
A MSO.SAN.FRAN.PORT.CHANGE RANDOM STEP VARIABLE,
A MOS.TODD.PORT.CHANGE RANDOM STEP VARIABLE,
A MSO.T.I.PORT.CHANGE RANDOM STEP VARIABLE,
A MSO.MERRI.PORT.CHANGE RANDOM STEP VARIABLE,
A MSO.PACIF.PORT.CHANGE RANDOM STEP VARIABLE,
A MSO.DEPLOY RANDOM STEP VARIABLE,
A REQ.PRIORITY
RANDOM STEP VARIABLE,
A ALAM.SHIP.INTER.DEPARTURE RANDOM LINEAR VARIABLE,
A DEPLOY.TIME RANDOM LINEAR VARIABLE,
A AE.REQ.PER.BUNDLE RANDOM LINEAR VARIABLE,
A MARE.ISLAND.SHIP.INTER.DEPARTURE RANDOM LINEAR
VARIABLE,
A AFS.REQ.PER.BUNDLE RANDOM LINEAR VARIABLE,
A AOR.REQ.PER.BUNDLE RANDOM LINEAR VARIABLE,
A MSO.REQ.PER.BUNDLE RANDOM LINEAR VARIABLE,
A AR.REQ.PER.BUNDLE RANDOM LINEAR VARIABLE,
A AE.QUAN.PER.REQ RANDOM LINEAR VARIABLE,
A AFS.QUAN.PER.REQ RANDOM LINEAR VARIABLE,
A AOR.QUAN.PER.REQ RANDOM LINEAR VARIABLE,
A MSO.QUAN.PER.REQ RANDOM LINEAR VARIABLE,
A AR.QUAN.PER.REQ RANDOM LINEAR VARIABLE,
A 1.ISSUE.GROUP.PROCESS.TIME RANDOM LINEAR VARIABLE,
A 2.ISSUE.GROUP.PROCESS.TIME RANDOM LINEAR VARIABLE,
A 3.ISSUE.GROUP.PROCESS.TIME
RANDOM LINEAR VARIABLE

DEFINE LOCATION,TYPE,SORCE,NUMBER.OF.REQUISITIONS,OWNER,
    PRIORITY,QUANTITY,BOAT,ITEM,ORDER,TUG AND
    PLACE AS INTEGER VARIABLES
DEFINE CHANGE AND NR.TRUCKS AS 1-DIMENSIONAL ARRAYS
''
STATISTICS ARE COMPUTED IN THE FOLLOWING STATEMENTS
''
TALLY MEAN.1.WAIT.TIME AS THE MEAN, VAR.1.WAIT.TIME
    AS THE VARIANCE, SD.1.WAIT.TIME AS THE STD.DEV.
              MAX.1.WAIT.TIME AS THE MAXIMUM,
              MIN.1.WAIT.TIME
    AS THE MINIMUM OF 1.WAIT.TIME
TALLY MEAN.2.WAIT.TIME AS THE MEAN, VAR.2.WAIT.TIME
    AS THE VARIANCE, SD.2.WAIT.TIME AS THE STD.DEV.
              MAX.2.WAIT.TIME AS THE MAXIMUM,
              MIN.2.WAIT.TIME
    AS THE MINIMUM OF 2.WAIT.TIME
TALLY MEAN.3.WAIT.TIME AS THE MEAN, VAR.3.WAIT.TIME
    AS THE VARIANCE, SD.3.WAIT.TIME AS THE STD.DEV.
              MAX.3.WAIT.TIME AS THE MAXIMUM,
              MIN.3.WAIT.TIME
    AS THE MINIMUM OF 3.WAIT.TIME
```

```
TALLY  M.WT.FINAL AS THE MEAN,V.WT.FINAL AS THE STD.DEV ,
MX.WT.FINAL AS
THE MAXIMUM,MIN.WT.FINAL AS THE MINIMUM OF WT.FINAL.SHIPPED
TALLY F.TOTAL.REQ AS THE SUM OF TOT.REQ
END
```

```
MAIN
''
THE NEXT TWO STATEMENTS DIMENSION VARIABLES
''
RESERVE CHANGE AS 5
RESERVE NR.TRUCKS AS 12
READ SEED.V(1)
''
THE NUMBER OF SHIPS IS READ
''
READ N.SHIP
CREATE EVERY SHIP
     FOR EVERY SHIP READ TYPE(SHIP), LOCATION(SHIP)
''
THE NUMBER OF PORTS IS READ
''
READ N.PORT
CREATE EVERY PORT
     FOR EVERY SHIP FILE THIS SHIP IN
      SHIP.QUEUE(LOCATION(SHIP))
PRINT 1 LINE THUS
               PORT     SHIP NR.
     FOR EVERY PORT DO THIS
        PRINT 1 LINE WITH PORT,N.SHIP.QUEUE(PORT) AS FOLLOWS
                 **         **
LOOP
FOR EACH SHIP PRINT 1 LINE WITH SHIP, LOCATION(SHIP),
TYPE(SHIP)
AS FOLLOWS
         **           **          **
''
THE FOLLOWING LINES READ IN THE SYSTEM PARAMETERS
''
READ SAN.FRAN.SHIP.INTER.DEPARTURE,
BETH.STL.SHIP.INTER.DEPARTURE.
     AE.1UNDLE.INTER.ARRIVAL,
     AFS.1UNDLE.INTER.ARRIVAL.
     AOR.1UNDLE.INTER.ARRIVAL.
     MSO.1UNDLE.INTER.ARRIVAL.
     AF.1UNDLE.INTER.ARRIVAL.
    AE.ALAM.PORT.CHANGE,
    AE.MARE.ISL.PORT.CHANGE.
    AE.WEAP.STA.PORT.CHANGE.
    AE.NSC.OAK.PORT.CHANGE.
    AE.SAN.FRAN.PORT.CHANGE,
    AE.TODD.PORT.CHANGE,
    AE.BETH.STL.PORT.CHANGE,
    AE.DEPLOY,
    AOR.ALAM.PORT.CHANGE.
    AOR.NSC.OAK.PORT.CHANGE,
    AOR.TODD.PORT.CHANGE.
    AOR.BETH.PORT.CHANGE.
    AOR.DEPLOY,
    AFS.ALAM.PORT.CHANGE.
    AFS.NSC.OAK.PORT.CHANGE,
    ASF.TODD.PORT.CHANGE.
    AFS.TRIP.A.PORT.CHANGE,
    AFS.DEPLOY.
    AR.ALAM.PORT.CHANGE,
    AR.MARE.ISL.PORT.CHANGE.
    AR.NSC.OAK.PORT.CHANGE.
    AR.DEPLOY READ
    MSO.ALAM.PORT.CHANGE.
    MSO.SAN.FRAN.PORT.CHANGE,
```

```
     MCS.TODD.PORT.CHANGE,
     MSC.T.I.PORT.CHANGE,
     MSC.MERRI.PORT.CHANGE,
     MSC.PACIF.PORT.CHANGE,
      MSC.DEPLOY,
     REC.PRIORITY,
        ALAM.SHIP.INTER.DEPARTURE,
     MARE.ISLAND.SHIP.INTER.DEPARTURE,
     AE.REQ.PER.BUNDLE,
     AFS.REQ.PER.BUNDLE,
     AOR.REQ.PER.BUNDLE,
     MSC.REQ.PER.BUNDLE,
     AR.REQ.PER.BUNDLE,
     AE.QUAN.PER.REQ,
     AFS.QUAN.PER.REQ,
     AOR.QUAN.PER.REQ,
     MSC.QUAN.PER.REQ,
     AR.QUAN.PER.REQ,
       DEPLOY.TIME,
     1.ISSUE.GROUP.PROCESS.TIME,
     2.ISSUE.GROUP.PROCESS.TIME,
     3.ISSUE.GROUP.PROCESS.TIME
      FOR EVERY SHIP DO THIS
''
THIS SECTION SCHEDULES THE INITIAL BUNDLE
PREPARATIONS BY EACH SHIP USING CLASS PARAMETERS
''
IF TYPE(SHIP) EQUALS 1
      SCHEDULE A BNDLE.PREPARATION
    GIVEN SHIP    IN AE.BUNDLE.INTER.ARRIVAL DAYS
ELSE
IF TYPE(SHIP) EQUALS 2
      SCHEDULE A BNDLE.PREPARATION
         GIVEN SHIP    IN AOR.BUNDLE.INTER.ARRIVAL DAYS
ELSE
IF TYPE(SHIP) EQUALS 3
      SCHEDULE A BNDLE.PREPARATION
              GIVEN SHIP    IN AFS.BUNDLE.INTER.ARRIVAL DAYS
ELSE
IF TYPE(SHIP) EQUALS 4
      SCHEDULE A BNDLE.PREPARATION
         GIVEN SHIP    IN MSC.BUNDLE.INTER.ARRIVAL DAYS
ELSE
    SCHEDULE A BNDLE.PREPARATION GIVEN SHIP
    IN AF.BUNDLE.INTER.ARRIVAL DAYS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
''
THE NEXT PORT MOVEMENT IS SCHEDULED BASED ON THE SHIP'S
CURRENT LOCATION
''
    IF LOCATION(SHIP) EQUALS 1 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN ALAM.SHIP.INTER.DEPARTURE DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 2 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN MARE.ISLAND.SHIP.INTER.DEPARTURE DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 3 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN EXPONENTIAL.F(16.3333,1) DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 4 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN UNIFORM.F(9.,56.,1) DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 5 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN SAN.FRAN.SHIP.INTER.DEPARTURE DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 6 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN UNIFORM.F(30.,84.,1) DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 7 SCHEDULE A CHANGE.LOCATION
```

```
    GIVEN SHIP IN BETH.STL.SHIP.INTER.DEPARTURE DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 8 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN DEPLOY.TIME DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 9 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN 7 DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 10 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN UNIFORM.F(3.,78.,1) DAYS
ELSE
    IF LOCATION(SHIP) EQUALS 11 SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN 44 DAYS
ELSE
     SCHEDULE A CHANGE.LOCATION
    GIVEN SHIP IN 44 DAYS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
LOOP
''
THE STEADY-STATE EVENT IS SCHEDULED
''
SCHEDULE AN EQUILIBRIUM IN 14. DAYS
      SCHEDULE A STOP.SIMULATION IN 379. DAYS
''
THE INITIAL SHIPMENT FROM EACH PORT IS SCHEDULED
''
      FOR EVERY PORT SCHEDULE A SHIPMENT.TO GIVEN
      PORT IN 1. DAY
START SIMULATION
STOP
END
```

```
EVENT EQUILIBRIUM
''
STATISTICS ARE RESET FOR STEADY-STATE
''
RESET THE TOTALS OF 1.WAIT.TIME, 2.WAIT.TIME AND 3.WAIT.TIME
FOR EACH PORT RESET TOTALS OF WT.FINAL.SHIPPED AND
      TOT.REQ
FOR EACH SHIP, DO
      LET T.SHIPPED(SHIP) = 0
      LET T.CHANGE(SHIP) = 0
LOOP
RETURN
END
```

```
EVENT  BNDLE.PREPARATION GIVEN VESSEL
DEFINE VESSEL AS AN INTEGER VARIABLE
''
THE NEXT BUNDLE PREPARATION FOR EACH VESSEL IS DETERMINED
AND SCHEDULED
''
IF TYPE(VESSEL) EQUALS 1
       SCHEDULE A BNDLE.PREPARATION
    GIVEN VESSEL IN AE.IUNDLE.INTER.ARRIVAL DAYS
ELSE
IF TYPE(VESSEL) EQUALS 2
       SCHEDULE A BNDLE.PREPARATION
         GIVEN VESSEL IN AOR.IUNDLE.INTER.ARRIVAL DAYS
ELSE
IF TYPE(VESSEL) EQUALS 3
       SCHEDULE A BNDLE.PREPARATION
             GIVEN VESSEL IN AFS.IUNDLE.INTER.ARRIVAL DAYS
ELSE
IF TYPE(VESSEL) EQUALS 4
       SCHEDULE A BNDLE.PREPARATION
         GIVEN VESSEL IN MSO.IUNDLE.INTER.ARRIVAL DAYS
ELSE
    SCHEDULE A BNDLE.PREPARATION GIVEN VESSEL
    IN AF.IUNDLE.INTER.ARRIVAL DAYS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
''
THE NUMBER OF REQUISITIONS PER BUNDLE AND
THE OWNER OF THE BUNDLE IS DETERMINED
''
CREATE A BUNDLE
    LET SORCE(BUNDLE) = VESSEL
IF TYPE(VESSEL) EQUALS 1
     LET NUMBER.OF.REQUISITIONS(BUNDLE) =
    INT.F(AE.REC.PER.BUNDLE)
ELSE
         IF TYPE(VESSEL) EQUALS 2
     LET NUMBER.OF.REQUISITIONS(BUNDLE) =
    INT.F(AOR.REQ.PER.BUNDLE)
ELSE
              IF TYPE(VESSEL) EQUALS 3
     LET NUMBER.OF.REQUISITIONS(BUNDLE) =
    INT.F(AFS.REQ.PER.BUNDLE)
ELSE
         IF TYPE(VESSEL) EQUALS 4
      LET NUMBER.OF.REQUISITIONS(BUNDLE) =
    INT.F(MSC.REQ.PER.BUNDLE)
ELSE
      LET NUMBER.OF.REQUISITIONS(BUNDLE) =
    INT.F(AR.REQ.PER.BUNDLE)
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
''
THE ARRIVAL TIME OF THIS BUNDLE IS SCHEDULED
''
SCHEDULE A ARRIVAL.OF.BUNDLE GIVEN BUNDLE IN
    EXPONENTIAL.F(8.886,1) DAYS
RETURN
END
```

```
EVENT ARRIVAL.OF.BUNDLE GIVEN PACKAGE
DEFINE PACKAGE AS AN INTEGER VARIABLE
''
AS EACH BUNDLE ARRIVES IT IS REDUCED TO
THE TOTAL NUMBER OF REQUISITIONS AND EACH REQUISITION
IS ASSIGNED ITS ATTRIBUTES
''
FOR I = 1 TO NUMBER.OF.REQUISITIONS(PACKAGE) DO THIS
    CREATE A REQUISITION
       LET OWNER(REQUISITION) = SORCE(PACKAGE)
       LET WEIGHT(REQUISITION) = EXPONENTIAL.F(2.,1)
       LET VOLUME(REQUISITION) = EXPONENTIAL.F(2.,1)
       LET PRIORITY(REQUISITION) = REQ.PRIORITY
       IF SORCE(PACKAGE) < 9    LET QUANTITY(REQUISITION) =
  INT.F(AE.QUAN.PER.REQ)
       ELSE
       IF SORCE(PACKAGE)  < 12    LET QUANTITY(REQUISITION) =
  INT.F(AOR.QUAN.PER.REQ)
       ELSE
       IF SORCE(PACKAGE)  < 15    LET QUANTITY(REQUISITION) =
  INT.F(AFS.QUAN.PER.REQ)
       ELSE
       IF SORCE(PACKAGE)  < 17    LET QUANTITY(REQUISITION) =
  INT.F(MSO.QUAN.PER.REQ)
       ELSE
        LET QUANTITY(REQUISITION) = INT.F(AR.QUAN.PER.REQ)
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
''
THE PROCESSING TIME FOR EACH REQUISITION IS DETERMINED
AND ITS READY FOR SHIPMENT TIME IS SCHEDULED
''
    IF PRIORITY(REQUISITION) EQUALS 3 SCHEDULE A
      READY.FOR.SHIPMENT GIVEN REQUISITION
                         IN 3.ISSUE.GROUP.PROCESS.TIME DAYS
ELSE
    IF PRIORITY(REQUISITION) EQUALS 2 SCHEDULE A
      READY.FOR.SHIPMENT GIVEN REQUISITION
                         IN 2.ISSUE.GROUP.PROCESS.TIME DAYS
ELSE
    SCHEDULE A READY.FOR.SHIPMENT GIVEN REQUISITION
                         IN 1.ISSUE.GROUP.PROCESS.TIME DAYS
REGARDLESS
REGARDLESS
LOOP
''
THE BUNDLE IS REMOVED FROM THE SYSTEM AND MEMORY IS
MADE AVAILABLE
''
DESTROY THE BUNDLE CALLED PACKAGE
RETURN
END
```

```
EVENT CHANGE.LOCATION GIVEN VESSEL
DEFINE VESSEL AND OLD.LOCATION AS INTEGER VARIABLES
''
THE VESSEL MOVEMENT STATISTICS ARE COMPUTED
''
ADD 1 TO  T.CHANGE(VESSEL)
ADD 1 TO CHANGE(TYPE(VESSEL))
''
THIS SECTION LOCATES THE NEXT PORT THE SHIP IS AT
''
LET OLD.LOCATION = LOCATION(VESSEL)
IF TYPE(VESSEL) EQUALS 1 AND OLD.LOCATION EQUALS 1
     LET LOCATION(VESSEL) = AE.ALAM.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 1 AND OLD.LOCATION EQUALS 2
     LET LOCATION(VESSEL) = AE.MARE.ISL.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 1 AND OLD.LOCATION EQUALS 3
LET LOCATION(VESSEL) = AE.WEAP.STA.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 1 AND OLD.LOCATION EQUALS 4
LET LOCATION(VESSEL) = AE.NSC.OAK.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 1 AND OLD.LOCATION EQUALS 5
LET LOCATION(VESSEL) = AE.SAN.FRAN.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 1 AND OLD.LOCATION              EQUALS 6
LET LOCATION(VESSEL) = AE.TCDD.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 1 AND OLD.LOCATION EQUALS 7
LET LOCATION(VESSEL) = AE.BETH.STL.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 1 AND OLD.LOCATION EQUALS 8
LET LOCATION(VESSEL) = AE.DEPLOY
ELSE
IF TYPE(VESSEL) EQUALS 2 AND OLD.LOCATION EQUALS 1
     LET LOCATION(VESSEL) = AOR.ALAM.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 2 AND OLD.LOCATION EQUALS 4
LET LOCATION(VESSEL) = AOR.NSC.OAK.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 2 AND OLD.LOCATION              EQUALS 6
LET LOCATION(VESSEL) = AOR.TCDD.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 2 AND OLD.LOCATION EQUALS 7
LET LOCATION(VESSEL) = AOR.BETH.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 2 AND OLD.LOCATION EQUALS 8
LET LOCATION(VESSEL) = AOR.DEPLOY
ELSE
IF TYPE(VESSEL) EQUALS 3 AND OLD.LOCATION EQUALS 1
     LET LOCATION(VESSEL) = AFS.ALAM.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 3 AND OLD.LOCATION EQUALS 4
LET LOCATION(VESSEL) = AFS.NSC.OAK.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 3 AND OLD.LOCATION              EQUALS 6
LET LOCATION(VESSEL) = ASF.TCDD.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 3 AND OLD.LOCATION EQUALS 8
LET LOCATION(VESSEL) = AFS.DEPLOY
ELSE
IF TYPE(VESSEL) EQUALS 3 AND OLD.LOCATION EQUALS 9
LET LOCATION(VESSEL) = AFS.TRIP.A.PORT.CHANGE
```

```
ELSE
IF TYPE(VESSEL) EQUALS 4 AND OLD.LOCATION EQUALS 1
     LET LOCATION(VESSEL) = MSO.ALAM.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 4 AND OLD.LOCATION EQUALS 5
LET LOCATION(VESSEL) = MSO.SAN.FRAN.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 4 AND OLD.LOCATION              EQUALS 6
LET LOCATION(VESSEL) = MOS.TODD.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 4 AND OLD.LOCATION EQUALS 8
LET LOCATION(VESSEL) = MSO.DEPLOY
ELSE
IF TYPE(VESSEL) EQUALS 4 AND OLD.LOCATION EQUALS 10
LET LOCATION(VESSEL) = MSO.T.I.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 4 AND OLD.LOCATION EQUALS 11
LET LOCATION(VESSEL) = MSO.MERRI.PORT.CHANGE
ELSE
LET LOCATION(VESSEL) = MSO.PACIF.PORT.CHANGE
IF TYPE(VESSEL) EQUALS 5 AND OLD.LOCATION EQUALS 1
     LET LOCATION(VESSEL) = AR.ALAM.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 5 AND OLD.LOCATION EQUALS 2
     LET LOCATION(VESSEL) = AR.MARE.ISL.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 5 AND OLD.LOCATION EQUALS 4
LET LOCATION(VESSEL) = AR.NSC.OAK.PORT.CHANGE
ELSE
IF TYPE(VESSEL) EQUALS 5 AND OLD.LOCATION EQUALS 8
LET LOCATION(VESSEL) = AR.DEPLOY
ELSE
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
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REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REMOVE THIS VESSEL FROM SHIP.QUEUE(OLD.LOCATION)
FILE THIS VESSEL IN SHIP.QUEUE(LOCATION(VESSEL))
''
THIS SECTION THEN SCHEDULES THE NEXT PORT CHANGE FOR THIS VE
''
     IF LOCATION(VESSEL) EQUALS 1 SCHEDULE A CHANGE.LOCATION
GIVEN VESSEL IN ALAM.SHIP.INTER.DEPARTURE DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 2 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN MARE.ISLAND.SHIP.INTER.DEPARTURE. DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 3 SCHEDULE A CHANGE.LOCATION
```

```
EVENT READY.FOR.SHIPMENT GIVEN REQ
DEFINE REQ AS AN INTEGER VARIABLE
''
THE SHIPPING DESTINATION IS FOUND AND TIME, WEIGHT, AND
VOLUME STATISTICS ARE COMPUTED
''
LET PORT = LOCATION(OWNER(REQ))
LET REQUISITION = REQ
FILE REQUISITION            IN THE SHIPPING.QUEUE(PORT)
LET TIME.READY.FOR.SHIP(REQ) = TIME.V
ADD QUANTITY(REQ)*WEIGHT(REQ) TO WT.SHIPPED(PORT)
ADD QUANTITY(REQ)*VOLUME(REQ) TO VOL.SHIPPED(PORT)
RETURN
END
```

```
     GIVEN VESSEL IN EXPONENTIAL.F(16.3333,1) DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 4 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN UNIFORM.F(9.,56.,1) DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 5 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN SAN.FRAN.SHIP.INTER.DEPARTURE DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 6 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN UNIFORM.F(30.,84.,1) DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 7 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN BETH.STL.SHIP.INTER.DEPARTURE DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 8 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN DEPLOY.TIME DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 9 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN 7 DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 10 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN UNIFORM.F(3.,78.,1) DAYS
ELSE
     IF LOCATION(VESSEL) EQUALS 11 SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN 44 DAYS
ELSE
      SCHEDULE A CHANGE.LOCATION
     GIVEN VESSEL IN 44 DAYS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
REGARDLESS
''
MATERIAL IS REMOVED FORM THE VESSEL'S OLD LOCATION QUEUE
AND ADDED TO THE VESSELS CURRENT LOCATION'S QUEUE
''
FOR EACH REQUISITION IN SHIPPING.QUEUE(OLD.LOCATION)
     WITH OWNER(REQUISITION) = VESSEL DO THIS
REMOVE THIS REQUISITION FROM SHIPPING.QUEUE(OLD.LOCATION)
 FILE THIS REQUISITION IN SHIPPING.QUEUE(LOCATION(VESSEL))
        SUBTRACT  QUANTITY(REQUISITION)* WEIGHT(REQUISITION)
FROM     WT.SHIPPED(OLD.LOCATION)
        SUBTRACT  QUANTITY(REQUISITION)* VOLUME(REQUISITION)
 FROM    VOL.SHIPPED(OLD.LOCATION)
        ADD QUANTITY(REQUISITION)* WEIGHT(REQUISITION) TO
          WT.SHIPPED(LOCATION(VESSEL))
       ADD QUANTITY(REQUISITION)* VOLUME(REQUISITION) TO
          VOL.SHIPPED(LOCATION(VESSEL))

LOOP
RETURN
END
```

```
EVENT SHIPMENT.TO GIVEN DESTINATION
DEFINE DESTINATION AS AN INTEGER VARIABLE
IF N.SHIPPING.QUEUE(DESTINATION) EQUALS 0
     GO TO 'FIRST'
ELSE
'SHIP'
''
STATISITICS ARE COMPUTED
''
ADD 1 TO NR.TRUCKS(DESTINATION)
LET WT.FINAL.SHIPPED(DESTINATION) = WT.SHIPPED(DESTINATION)
LET VOL.FINAL.SHIPPED(DESTINATION) =
VOL.SHIPPED(DESTINATION)
LET TOT.REQ(DESTINATION) = N.SHIPPING.QUEUE(DESTINATION)
LET WT.SHIPPED(DESTINATION) = 0
LET VOL.SHIPPED(DESTINATION) = 0
FOR EACH REQUISITION IN SHIPPING.QUEUE(DESTINATION)DO THIS
    IF PRIORITY(REQUISITION) = 1 LET 1.WAIT.TIME = TIME.V
    -TIME.READY.FOR.SHIP(REQUISITION)
ELSE
    IF PRIORITY(REQUISITION) = 2 LET 2.WAIT.TIME = TIME.V
    -TIME.READY.FOR.SHIP(REQUISITION)
ELSE
 LET 3.WAIT.TIME = TIME.V - TIME.READY.FOR.SHIP(REQUISITION)
REGARDLESS
REGARDLESS
ADD 1 TO T.SHIPPED(OWNER(REQUISITION))
REMOVE THE REQUISITION FROM SHIPPING.QUEUE(DESTINATION)
DESTROY REQUISITION
LOOP
'FIRST'
''
THE NEXT SHIPMENT FOR THIS PORT IS COMPUTED
AND SCHEDULED
''
IF TIME.V = INT.F(TIME.V)
SCHEDULE A SHIPMENT.TO GIVEN DESTINATION IN 1. DAY
ALWAYS
RETURN
END
```

```
EVENT STOP.SIMULATION
LET LINES.V = 48
LET PAGE.V = 1
BEGIN REPORT ON A NEW PAGE
BEGIN HEADING
PRINT 5 LINES     WITH PAGE.V AS FOLLOWS
                                SIMULATION RESULTS

                                                            PAGE NO. **

IF PAGE IS FIRST,
PRINT 23 LINES AS FOLLOWS
     THE EXECUTION TIME PARAMETER FOR THIS MODEL WAS 365 DAYS.  THE FOLLOWING
SECTION IDENTIFIES ALL CODES USED IN THE MAIN PROGRAM AND THE RESULTS SECTION:

     SHIP  CLASS NO. HULL NO.   PORT  LOCATION NAME

      1      1        AF 22       1    NAVAL AIR STATION ALAMADA
      2      1        AF 24       2    MARE ISLAND NAVAL SHIPYARD
      3      1        AF 25       3    NAVAL WEAPONS STATION CONCORD
      4      1        AF 26       4    NAVAL SUPPLY CENTER OAKLAND
      5      1        AF 27       5    SAN FRANCISCO
      6      1        AF 32       6    TODD SHIPYARD
      7      1        AF 33       7    BETH STL SHIPYARD
      8      1        AF 35       8    DEPLOYED
      9      2        AOR 1       9    TRIP A SHIPYARD
     10      2        AOR 3      10    NAVAL SUPPORT ACTIVITY TREASURE ISLAND
     11      2        AOR 5      11    MERDITH SHIPYARD
     12      3        AFS 1      12    PACIFIC DRYDOCK
     13      3        AFS 3
     14      3        AFS 7
     15      4        MSO 439
     16      4        MSO 489
     17      5        AR 7
REGARDLESS
END''HEADING
SKIP 17 OUTPUT LINES
PRINT 8 LINES THUS

     THE FOLLOWING STATISTICS REPRESENT LOST TIME FOR
ISSUE GROUP ONE REQUISITIONS WHILE IN THE SHIPPING QUEUE:

     MEAN        VARIANCE       STD DEV        MAX            MIN
```


A AF.IUNDLE.INTER.ARRIVAL RANDOM STEP VARIABLE.

```
PRINT 1 LINE WITH MEAN.1.WAIT.TIME, VAR.1.WAIT.TIME, SD.1.WAIT.TIME,
    MAX.1.WAIT.TIME, MIN.1.WAIT.TIME AS FOLLOWS
   ********.**    ********.**   ********.**   ********.**   ********.**
PRINT 6 LINES THUS

     THE FOLLOWING STATISTICS REPRESENT LOST TIME FOR
ISSUE GROUP TWO REQUISITIONS WHILE IN THE SHIPPING QUEUE:

     MEAN          VARIANCE        STD DEV         MAX             MIN

PRINT 1 LINE WITH MEAN.2.WAIT.TIME, VAR.2.WAIT.TIME, SD.2.WAIT.TIME,
    MAX.2.WAIT.TIME, MIN.2.WAIT.TIME AS FOLLOWS
   ********.**    ********.**   ********.**   ********.**   ********.**
PRINT 6 LINES THUS

     THE FOLLOWING STATISTICS REPRESENT LOST TIME FOR
ISSUE GROUP THREE REQUISITIONS WHILE IN THE SHIPPING QUEUE:

     MEAN          VARIANCE        STD DEV         MAX             MIN

PRINT 1 LINE WITH MEAN.3.WAIT.TIME, VAR.3.WAIT.TIME, SD.3.WAIT.TIME,
    MAX.3.WAIT.TIME, MIN.3.WAIT.TIME AS FOLLOWS
   ********.**    ********.**   ********.**   ********.**   ********.**
PRINT 8 LINES THUS


     THE FOLLOWING STATISTICS REPRESENT WEIGHT SHIPPED TO
VARIOUS DESTINATIONS :

  DESTINATION       MEAN        STD. DEV.        MAX           MIN           NR.REQ
                 WT.SHIPPED   WT.SHIPPED    WT.SHIPPED    WT.SHIPPED      SHIPPED

FOR EACH PORT PRINT 1 LINE WITH PORT,
M.WT.FINAL(PORT),V.WT.FINAL(PORT),MX.WT.FINAL(PORT),MIN.WT.FINAL(PORT),
F.TOTAL.REC(PORT) AS FOLLOWS
   ********.**    ********.**   ********.**   ********.**   ********.**   ********.**
SKIP 9 OUTPUT LINES
PRINT 7 LINES THUS


     THE SHIP,ITS FINAL PORT, THE TOTAL NUMBER OF REQUISITIONS
SHIPPED AND THE TOTAL NUMBER OF MOVES FOLLOWS:

   SHIP    PORT      NR.REQ     NR.MOVES

FOR EACH SHIP PRINT 1 LINE WITH SHIP, LOCATION(SHIP),
    T.SHIPPED(SHIP),T.CHANGE(SHIP) AS FOLLOWS
    **       **        *******      ***
```

```
PRINT 6 LINES THUS

THE SHIP CLASS AND ASSOCIATED NUMBER OF MOVES FOLLOWS:

        CLASS    NR.MOVES

FOR I = 1 TO 5
    PRINT 1 LINE WITH I, CHANGE(I) AS FOLLOWS
           **      ****
SKIP 5 OUTPUT LINES
PRINT 6 LINES THUS

THE NUMBER OF SHIPMENTS PER PORT FOLLOWS:

          PORT        SHIPMENTS

FOR J = 1 TO 12
PRINT 1 LINE WITH J, NR.TRUCKS(J) AS FOLLOWS
           **              ****
END''REPORT
STOP
END
```

MSC.SAN.FRAN.PORT.CHANGE,

65

APPENDIX E

CASE II

```
EVENT SHIPMENT.TO GIVEN DESTINATION
DEFINE DESTINATION AS AN INTEGER VARIABLE
IF N.SHIPPING.QUEUE(DESTINATION) EQUALS 0
     GO TO 'FIRST'
''
DECISION RULES FOR CASE II
''
IF INT.F(TIME.V/7.) EQUALS TIME.V/7.
     GO TO 'SHIP'
ELSE
     GO TO 'FIRST'
ELSE
'SHIP'
''
STATISITICS ARE COMPUTED
''
ADD 1 TO NR.TRUCKS(DESTINATION)
LET WT.FINAL.SHIPPED(DESTINATION) = WT.SHIPPED(DESTINATION)
LET VOL.FINAL.SHIPPED(DESTINATION) =
VOL.SHIPPED(DESTINATION)
LET TOT.REQ(DESTINATION) = N.SHIPPING.QUEUE(DESTINATION)
LET WT.SHIPPED(DESTINATION) = 0
LET VOL.SHIPPED(DESTINATION) = 0
FOR EACH REQUISITION IN SHIPPING.QUEUE(DESTINATION)DO THIS
    IF PRIORITY(REQUISITION) = 1 LET 1.WAIT.TIME = TIME.V
    -TIME.READY.FOR.SHIP(REQUISITION)
ELSE
    IF PRIORITY(REQUISITION) = 2 LET 2.WAIT.TIME = TIME.V
    -TIME.READY.FOR.SHIP(REQUISITION)
ELSE
 LET 3.WAIT.TIME = TIME.V - TIME.READY.FOR.SHIP(REQUISITION)
REGARDLESS
REGARDLESS
ADD 1 TO T.SHIPPED(OWNER(REQUISITION))
REMOVE THE REQUISITION FROM SHIPPING.QUEUE(DESTINATION)
DESTROY REQUISITION
LOOP
'FIRST'
''
THE NEXT SHIPMENT FOR THIS PORT IS COMPUTED
AND SCHEDULED
''
IF TIME.V = INT.F(TIME.V)
SCHEDULE A SHIPMENT.TO GIVEN DESTINATION IN 1. DAY
ALWAYS
RETURN
END
```

APPENDIX F

CASE III

```
EVENT READY.FOR.SHIPMENT GIVEN REQ
DEFINE REQ AS AN INTEGER VARIABLE
''
THE SHIPPING DESTINATION IS FOUND AND TIME, WEIGHT, AND
VOLUME STATISTICS ARE COMPUTED
''
LET PORT = LOCATION(OWNER(REQ))
LET REQUISITION = REQ
FILE REQUISITION           IN THE SHIPPING.QUEUE(PORT)
LET TIME.READY.FOR.SHIP(REQ) = TIME.V
ADD QUANTITY(REQ)*WEIGHT(REQ) TO WT.SHIPPED(PORT)
ADD QUANTITY(REQ)*VOLUME(REQ) TO VOL.SHIPPED(PORT)
''
DECISION RULES FOR CASE III
''
IF PRIORITY(REQ) EQUALS 1 SCHEDULE A SHIPMENT.TO GIVEN
PORT NOW
ALWAYS
RETURN
END
```

APPENDIX G

CASE IV

```
EVENT SHIPMENT.TO GIVEN DESTINATION
DEFINE DESTINATION AS AN INTEGER VARIABLE
IF N.SHIPPING.QUEUE(DESTINATION) EQUALS 0
     GO TO 'FIRST'
''
DECISION RULES FOR CASE II
''
IF INT.F(TIME.V/7.) EQUALS TIME.V/7.
     GO TO 'SHIP'
ELSE
''
DECISION RULES FOR CASE IV
''
FOR EACH REQUISITION IN SHIPPING.QUEUE(DESTINATION)
      WITH PRIORITY(REQUISITION) < 3. FIND THE FIRST CASE
      IF NONE, GO TO FIRST
ELSE
'SHIP'
''
STATISITICS ARE COMPUTED
''
ADD 1 TO NR.TRUCKS(DESTINATION)
LET WT.FINAL.SHIPPED(DESTINATION) = WT.SHIPPED(DESTINATION)
LET VOL.FINAL.SHIPPED(DESTINATION) =
VOL.SHIPPED(DESTINATION)
LET TOT.REQ(DESTINATION) = N.SHIPPING.QUEUE(DESTINATION)
LET WT.SHIPPED(DESTINATION) = 0
LET VOL.SHIPPED(DESTINATION) = 0
FOR EACH REQUISITION IN SHIPPING.QUEUE(DESTINATION)DO THIS
     IF PRIORITY(REQUISITION) = 1 LET 1.WAIT.TIME = TIME.V
     -TIME.READY.FOR.SHIP(REQUISITION)
ELSE
     IF PRIORITY(REQUISITION) = 2 LET 2.WAIT.TIME = TIME.V
     -TIME.READY.FOR.SHIP(REQUISITION)
ELSE
 LET 3.WAIT.TIME = TIME.V - TIME.READY.FOR.SHIP(REQUISITION)
REGARDLESS
REGARDLESS
ADD 1 TO T.SHIPPED(OWNER(REQUISITION))
REMOVE THE REQUISITION FROM SHIPPING.QUEUE(DESTINATION)
DESTROY REQUISITION
LOOP
'FIRST'
''
THE NEXT SHIPMENT FOR THIS PORT IS COMPUTED
AND SCHEDULED
''
IF TIME.V = INT.F(TIME.V)
SCHEDULE A SHIPMENT.TO GIVEN DESTINATION IN 1. DAY
ALWAYS
RETURN
END
```

APPENDIX H

DETAILED RESULTS CASE I

TRIAL	ISSUE GROUP	MEAN TIME	STD DEV	MAX TIME	MIN TIME	TOTAL TRIPS
1	1	.47	.28	.98	.01	
1	2	.50	.29	1.00	.00	
1	3	.50	.29	1.00	.00	2051
2	1	.47	.29	.99	.00	
2	2	.50	.29	1.00	.00	
2	3	.50	.29	1.00	.00	2231
3	1	.49	.29	.95	.00	
3	2	.50	.29	1.00	.00	
3	3	.50	.29	1.00	.00	1885
4	1	.48	.28	.96	.02	
4	2	.50	.29	1.00	.00	
4	3	.50	.29	1.00	.00	2267
5	1	.46	.32	.99	.01	
5	2	.50	.29	1.00	.00	
5	3	.50	.29	1.00	.00	2273
6	1	.52	.28	1.00	.06	
6	2	.50	.29	1.00	.00	
6	3	.50	.29	1.00	.00	1947
7	1	.48	.30	1.00	.01	
7	2	.50	.29	1.00	.00	

7	3	.50	.29	1.00	.00	2079
8	1	.50	.29	1.00	.00	
8	2	.50	.29	1.00	.00	
8	3	.50	.29	1.00	.00	2034
9	1	.52	.30	1.00	.00	
9	2	.50	.29	1.00	.00	
9	3	.50	.29	1.00	.00	2314
10*						

CASE II

TRIAL	ISSUE GROUP	MEAN TIME	STD DEV	MAX TIME	MIN TIME	TOTAL TRIPS
1*						
2	1	3.61	1.91	6.33	.17	
2	2	3.60	2.00	7.00	.00	
2	3	3.61	1.99	7.00	.00	332
3	1	3.60	1.71	6.93	.04	
3	2	3.43	2.01	7.00	.00	
3	3	3.41	2.00	7.00	.00	336
4*						
5	1	3.47	2.02	6.97	.02	
5	2	3.51	2.05	7.00	.00	
5	3	3.49	2.07	7.00	.00	341
6	1	3.45	1.88	6.90	.06	
6	2	3.52	2.00	7.00	.00	
6	3	3.53	2.01	7.00	.00	283
7*						
8	1	3.27	1.91	6.96	.43	
8	2	3.52	2.02	7.00	.00	
8	3	3.52	2.01	7.00	.00	303
9*						

10*

CASE III

TRIAL	ISSUE GROUP	MEAN TIME	STD DEV	MAX TIME	MIN TIME	TOTAL TRIPS
1*						
2	1	.00	.00	.00	.00	
2	2	2.92	1.99	7.00	.00	
2	3	2.93	1.99	7.00	.00	403
3	1	.00	.00	.00	.00	
3	2	2.91	2.00	7.00	.00	
3	3	2.89	1.98	7.00	.00	400
4	1	.00	.00	.00	.00	
4	2	2.90	1.98	7.00	.00	
4	3	2.89	1.98	7.00	.00	413
5	1	.00	.00	.00	.00	
5	2	2.96	1.99	7.00	.00	
5	3	2.93	2.01	7.00	.00	397
6	1	.00	.00	.00	.00	
6	2	2.80	1.95	7.00	.00	
6	3	2.78	1.95	7.00	.00	370
7*						
8	1	.00	.00	.00	.00	
8	2	3.04	2.02	7.00	.00	
8	3	3.04	2.01	7.00	.00	363
9*						
10*						

CASE IV

TRIAL	ISSUE GROUP	MEAN TIME	STD DEV	MAX TIME	MIN TIME	TOTAL TRIPS

1	1	.00	.00	.00	.00	
1	2	.49	.29	1.00	.00	
1	3	.51	.38	6.69	.00	1788
2	1	.00	.00	.00	.00	
2	2	.48	.29	1.00	.00	
2	3	.52	.41	6.95	.00	1865
3	1	.00	.00	.00	.00	
3	2	.49	.29	1.00	.00	
3	3	.52	.38	6.98	.00	1995
4	1	.00	.00	.00	.00	
4	2	.48	.29	1.00	.00	
4	3	.53	.42	6.89	.00	1901
5	1	.00	.00	.00	.00	
5	2	.49	.29	1.00	.00	
5	3	.52	.38	6.87	.00	1920
6	1	.00	.00	.00	.00	
6	2	.49	.29	1.00	.00	
6	3	.51	.37	6.91	.00	1690
7	1	.00	.00	.00	.00	
7	2	.49	.29	1.00	.00	
7	3	.52	.38	6.99	.00	1752
8	1	.00	.00	.00	.00	
8	2	.49	.29	1.00	.00	
8	3	.51	.36	6.93	.00	1797
9	1	.00	.00	.00	.00	
9	2	.49	.29	1.00	.00	
9	3	.52	.38	7.00	.00	2018

10*

*Results not available. Computer memory space required exceeds 430,000 bytes.

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